Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins

Part 7: Upper Willamette Steelhead

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Paul McElhany[1], Mark Chilcote[2], James Myers[1], Ray Beamesderfer[3]

[1] National Marine Fisheries Service Northwest Fisheries Science Center
[2] Oregon Department of Fish and Wildlife
[3] Cramer Fish Sciences

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I. ESU Overview and Historical Range

The Upper Willamette Steelhead ESU consists of four populations occupying watersheds as shown in Figure 1. The four populations in the ESU are the Molalla, North Santiam, South Santiam, and Calapooia. The West Side Tributaries represent an area of intermittent use by steelhead, which may be important for ESU recovery, but is not considered to have historically been an independent population (Myers et al. 2006). The population structure described here differs from the population structure reported in the Oregon Native Fish Status report (ODFW 2005). In its report, ODFW identified four populations on the west side of the Willamette Valley and segregated the South Santiam into upper and lower watersheds.

Steelhead in this ESU are depressed from historical levels, although to a much less extent than spring Chinook in the Willamette basin. Further, all of the historical populations remain extant with moderate numbers of wild steelhead produced each year. However these populations have been adversely impacted by the alteration and loss of spawning and rearing habitat associated with hydropower development. Hatchery reared winter steelhead are no longer released into any of the UW steelhead populations. However, introduced hatchery summer steelhead still occur in the North and South Santiam basins and also migrate via the mainstem Willamette River to the McKenzie River basin.

A time series of abundance is available for all four populations in the ESU (Appendix B). However, spawner abundance estimates, with the exception of the upper South Santiam, are based entirely on spawning surveys conducted for a small portion of the steelhead habitat. The results from these surveys are then expanded for the entire watershed to obtain an estimate for population abundance. As a consequence there is considerable uncertainty concerning the accuracy of these abundance estimates

The presentation of our assessment begins with three sections, each of which evaluates one of the viability criteria (i.e., abundance/productivity, spatial structure, and diversity). This is then followed by a synthesis section where we pool the results from these criteria evaluations into a status rating for each population. We end our presentation with an interpretation of the population results in terms of the overall status of this ESU. The methods are described in Part 1 of this report.

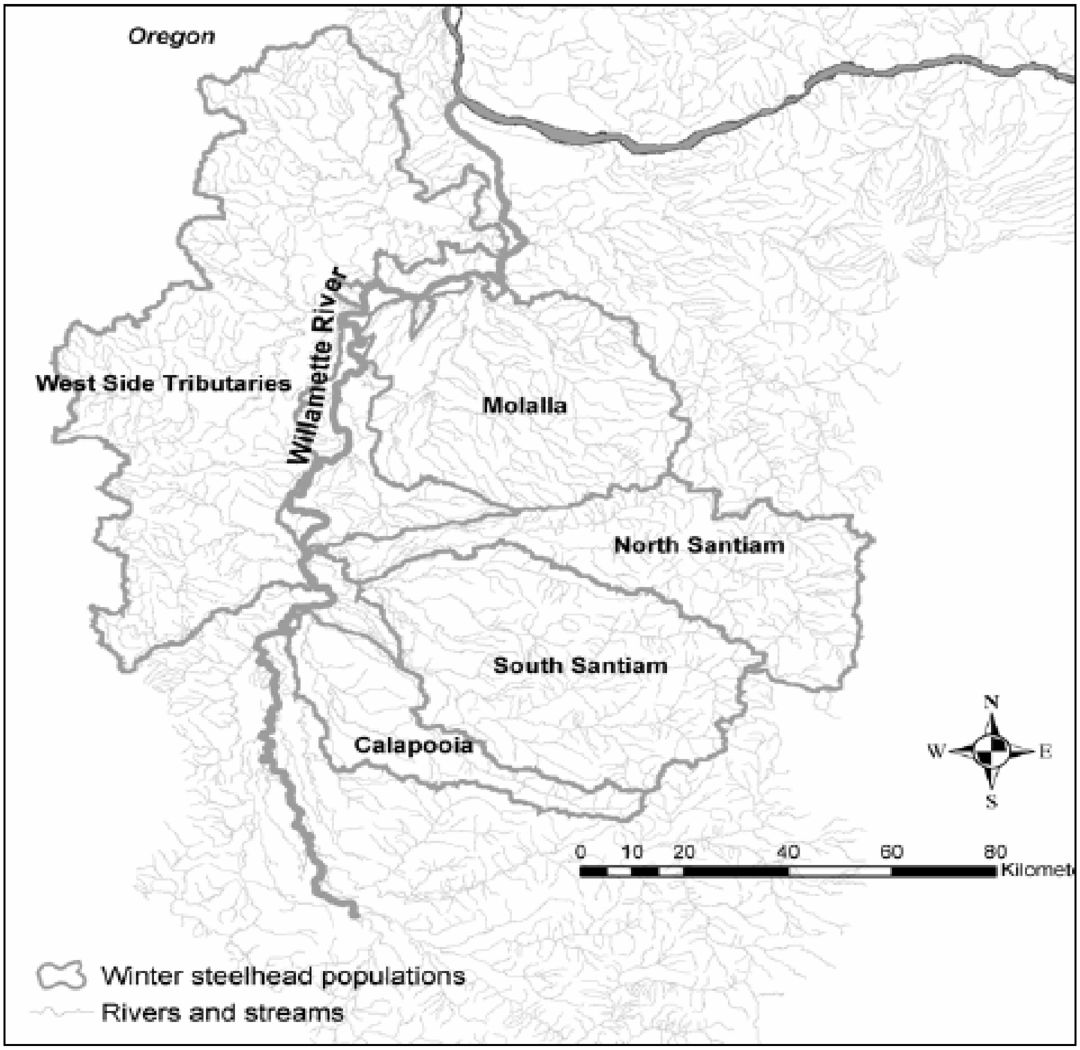

Figure 1: Map of populations in Upper Willamette winter steelhead ESU. The West Site Tributaries are considered an "intermittent use" area, not an independent population.

II. Abundance and Productivity

A&P – Molalla

A time series of abundance sufficient for quantitative analysis is available for the Molalla population (Appendix B). Descriptive graphs and viability analysis results are provided in Figure 2 to Figure 9 and in Table 1 and Table 4. The population is relatively large, with a long-term geometric mean natural origin spawner of 1,233 and a recent geometric mean of 937. These values are in the viable to very low risk minimum abundance threshold (MAT) category.

The modeling results reflect the uncertainty in the input data and therefore in the population status. The pre-harvest viability curve analyses suggest that the population is probably viable if harvest levels remain at current rates (average post-1990 fishery mortality rate = 0.10). The escapement viability curves suggest that the harvest pattern observed over the course of the time series which included a period of time when the fishery mortality rate was 0.23 is not likely to be sustainable by the population. Largely because of the high amount of measurement error in the input data, the "blobs" describing the current population status are relatively large and span all of the viability curve risk categories.

The CAPM analysis indicates that the population is very likely not viable and the predicted CRT risk probability over 100 years is around 24%. The PopCycle model suggests a CRT risk probability of around 21%. Overall, we estimate that the population is most likely in the moderate risk category based on abundance and productivity data, but the range of possibility spans the entire spectrum from very low risk to very high risk. The Oregon Native Fish Status report (ODFW 2005) gave this population a "pass" for abundance and productivity.

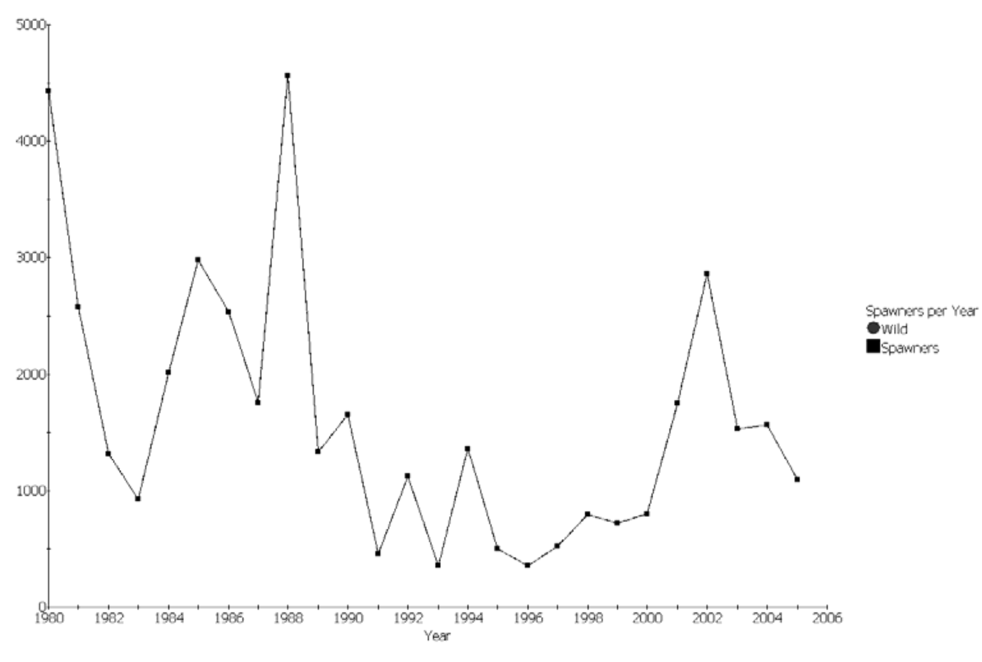

Figure 2: Molalla River winter steelhead abundance.

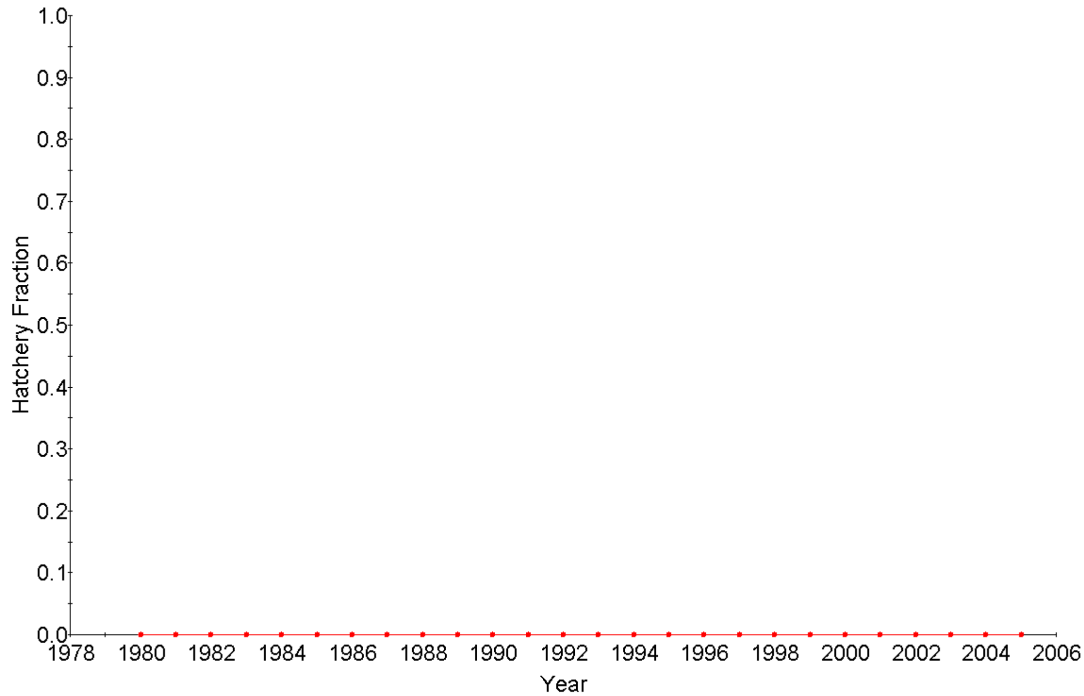

Figure 3: Molalla River winter steelhead hatchery fraction.

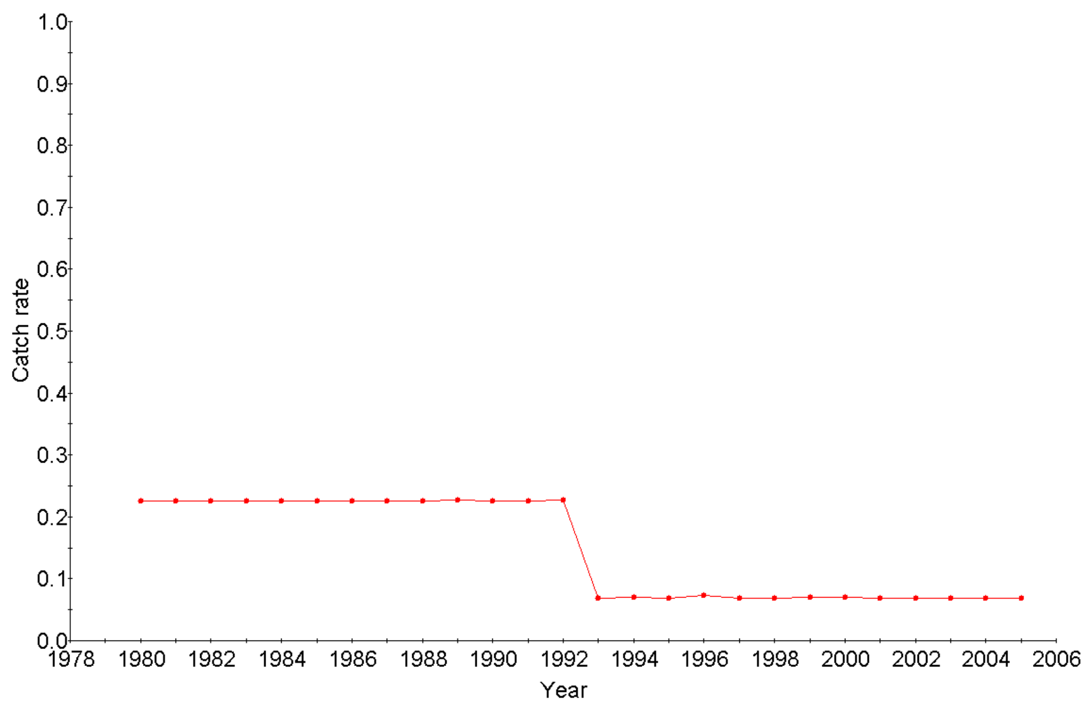

Figure 4: Molalla River winter steelhead harvest rate.

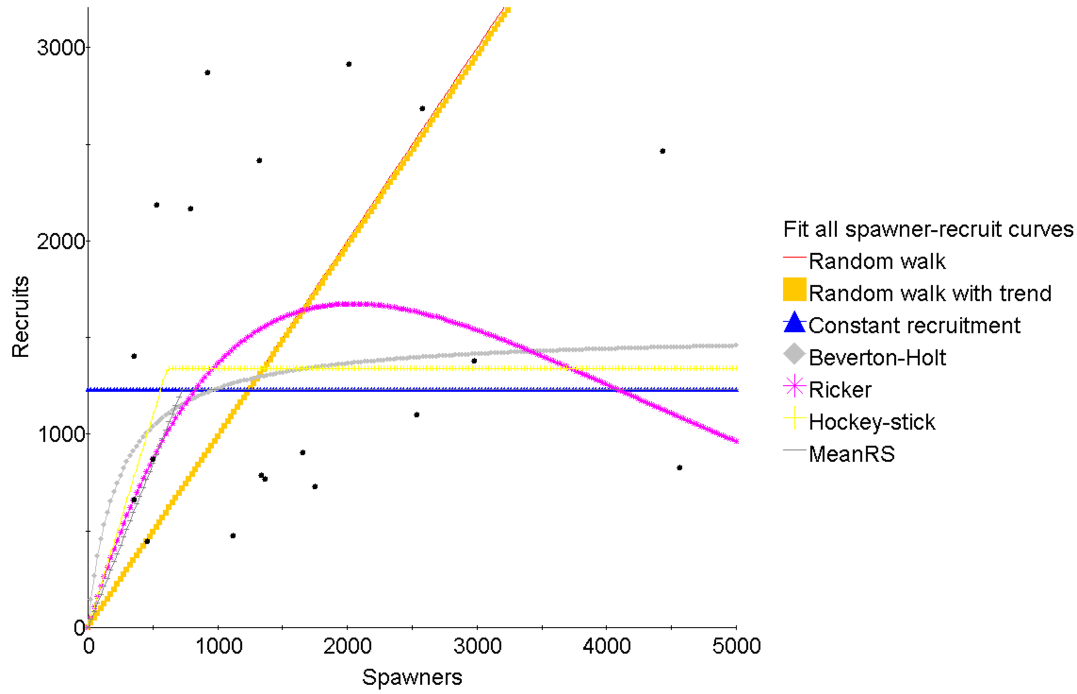

Figure 5: Molalla River winter steelhead escapement recruitment functions.

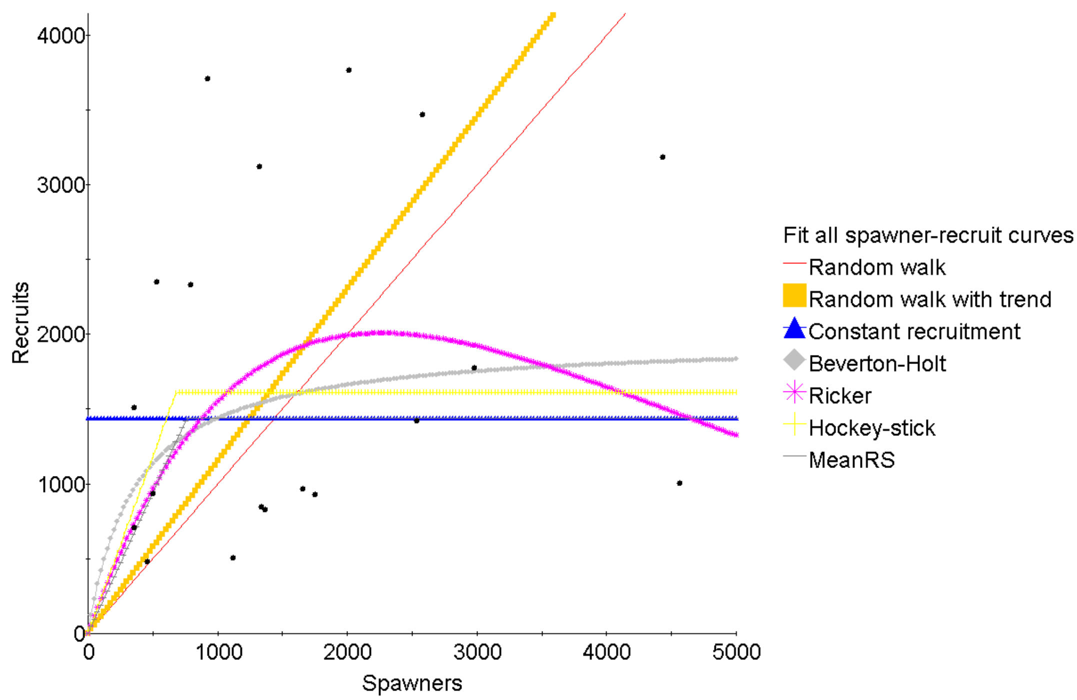

Figure 6: Molalla River winter steelhead pre-harvest recruitment functions.

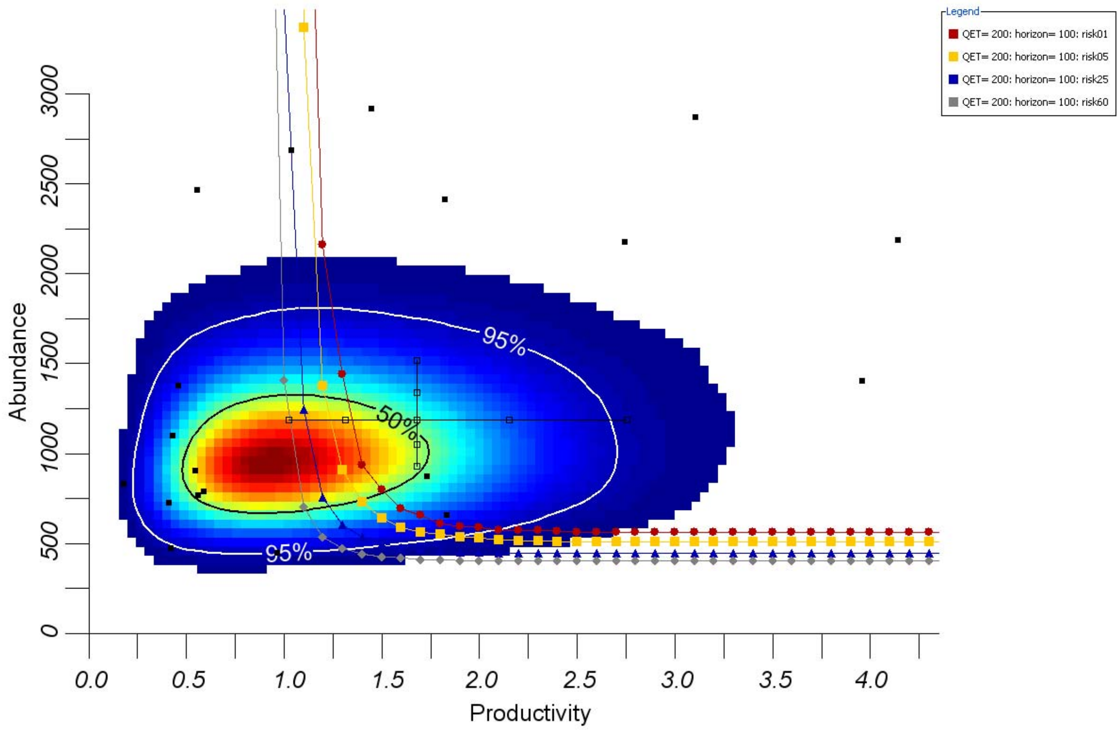

Figure 7: Molalla River winter steelhead escapement viability curves.

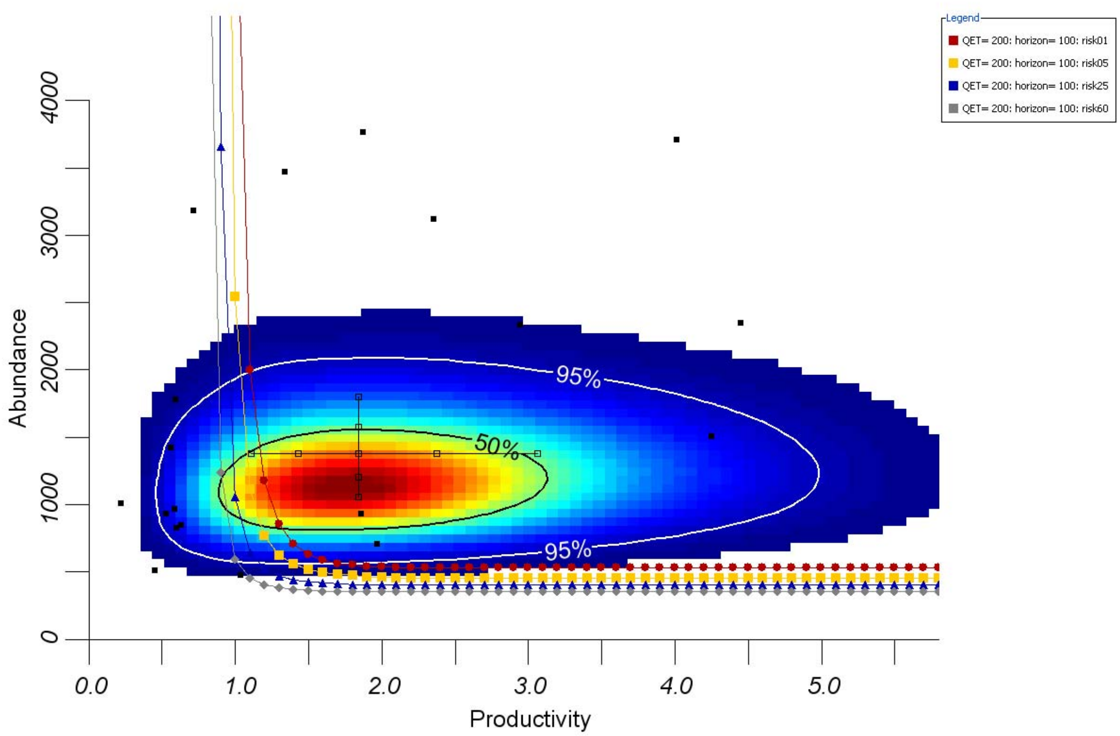

Figure 8: Molalla River winter steelhead pre-harvest viability curves.

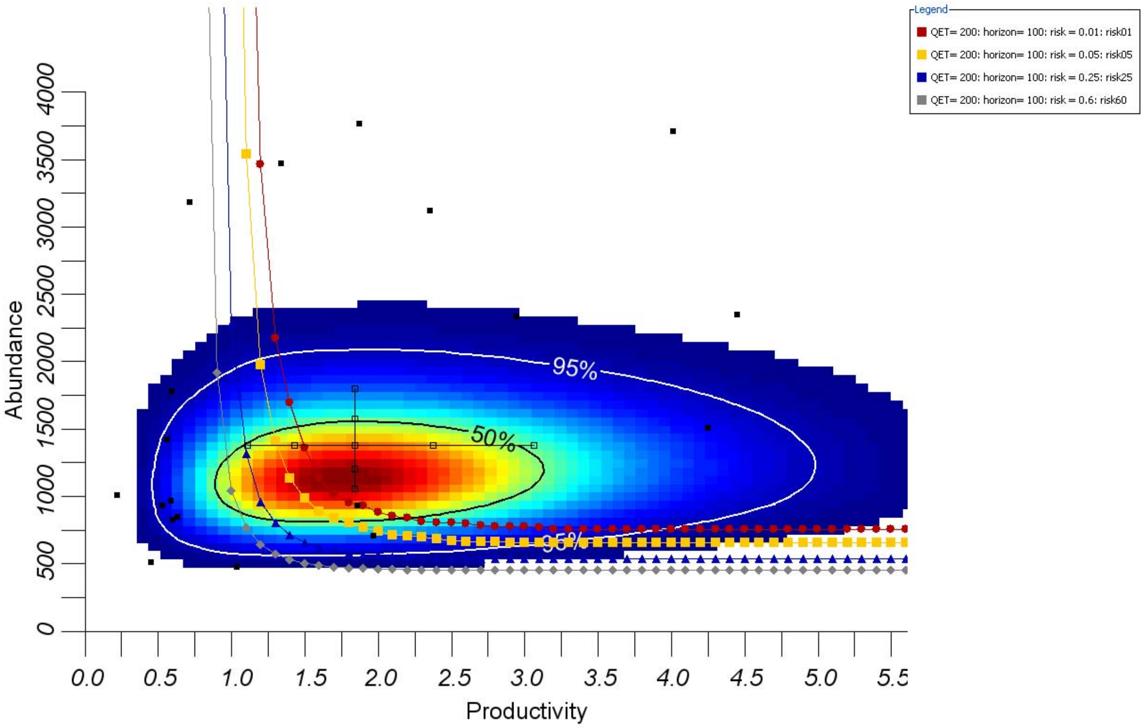

Figure 9: Molalla River winter steelhead pre-harvest viability curves.

Table 1: Molalla River winter steelhead summary statistics. The geometric mean natural origin spawner abundance (highlighted) is in the "viable" to "very low risk" viability criteria category. The 95% confidence intervals are shown in parentheses.

Statistic	Escapement		Pre-harvest	
	Total Series	**Recent Years**	**Total Series**	**Recent Years**
Time Series Period	1980-2005	1990-2005	1980-2005	1990-2005
Length of Time Series	26	16	26	16
Geometric Mean Natural Origin Spawner Abundance	1273 (952-1703)	914 (655-1275)	NA	NA
Geometric Mean Recruit Abundance	1233 (911-1669)	937 (595-1475)	1440 (1036-2001)	1006 (639-1584)
Lambda	0.988 (0.79-1.235)	1.058 (0.698-1.602)	1.016 (0.813-1.27)	1.066 (0.69-1.647)
Trend in Log Abundance	0.966 (0.931-1.002)	1.059 (0.989-1.132)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.985 (0.64-1.517)	1.378 (0.704-2.699)	1.15 (0.753-1.757)	1.48 (0.756-2.899)
Geometric Mean Recruits per Spawner (broods < median spawner abundance)	1.695 (0.97-2.963)	2.275 (1.268-4.081)	1.889 (1.064-3.353)	2.443 (1.361-4.384)
Average Hatchery Fraction	0	0	NA	NA
Average Harvest Rate	0.147	0.098	NA	NA
CAPM median extinction risk probability (5th and 95th percentiles in parenthesis)	NA	NA	0.240 (0.135-0.480)	NA
PopCycle extinction risk	NA	NA	0.21	NA

Table 2: Escapement recruitment parameter estimates and relative AIC values for Molalla winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.87 (0.71-1.24)	11.4
Random walk with trend	0.99 (0.72-1.51)	NA	0.87 (0.73-1.29)	13.4
Constant recruitment	NA	1232 (979-1643)	0.61 (0.51-0.91)	0
Beverton-Holt	6.5 (3-28.14)	1528 (1090-2335)	0.59 (0.5-0.9)	0.9
Ricker	2.23 (1.32-3.66)	1674 (1382-3172)	0.63 (0.54-0.99)	3.1
Hockey-stick	2.19 (2.2->30)	1339 (983-1682)	0.59 (0.51-0.9)	0.6
MeanRS	1.69 (1.14-2.46)	1233 (981-1554)	0.37 (0.24-0.47)	15

Table 3: Pre-harvest recruitment parameter estimates and relative AIC values for Molalla winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.87 (0.7-1.23)	8.1
Random walk with trend	1.15 (0.85-1.74)	NA	0.85 (0.71-1.26)	9.6
Constant recruitment	NA	1441 (1121-1965)	0.66 (0.55-0.99)	0
Beverton-Holt	5.34 (2.45->30)	1970 (1284-3610)	0.64 (0.54-0.96)	0.1
Ricker	2.41 (1.34-4.01)	2007 (1646-5365)	0.65 (0.56-1.04)	1.6
Hockey-stick	2.37 (2.21->30)	1610 (1129-2078)	0.63 (0.55-0.98)	0
MeanRS	1.89 (1.26-2.77)	1439 (1125-1850)	0.42 (0.27-0.54)	10.7

Table 4: Molalla River winter steelhead CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in "Extirpated or nearly so" category	0.682	0.922	0.982
Probability the population is above "Moderate risk of extinction" category	0.613	0.898	0.528
Probability the population is above "Viable" category	0.531	0.855	0.002
Probability the population is above "Very low risk of extinction" category	0.450	0.814	0.000

A&P – North Santiam

A time series of abundance sufficient for quantitative analysis is available for the North Santiam population (Appendix B). Descriptive graphs and viability analysis results are provided beginning with Figure 9 and in Table 5 and Table 8. The population is relatively large, with a long-term geometric mean natural origin spawner population of 2,722 and a recent geometric mean of 2,109 (Table 5). These values are in the very low risk minimum abundance threshold (MAT) category.

The modeling results reflect the uncertainty in the input data and therefore in the population status. The pre-harvest viability curve analyses suggest that the population is probably viable if harvest levels remain low. The escapement viability curves suggest that the harvest pattern observed over the course of the time series is likely to be sustainable. Largely because of the high amount of measurement error in the input data, the "blobs" describing the current population status are relatively large and span all of the viability curve risk categories.

The CAPM analysis indicates that the population is viable as evidenced by a median value for predicted CRT probabilities of 0.005. The PopCycle analysis also suggests a low risk (<0.01). We estimate that the population is most likely in the viable category, but the range of possibility spans the entire spectrum from very low risk to very high risk. The Oregon Native Fish Status report (ODFW 2005) gave this population a "pass" for abundance and productivity.

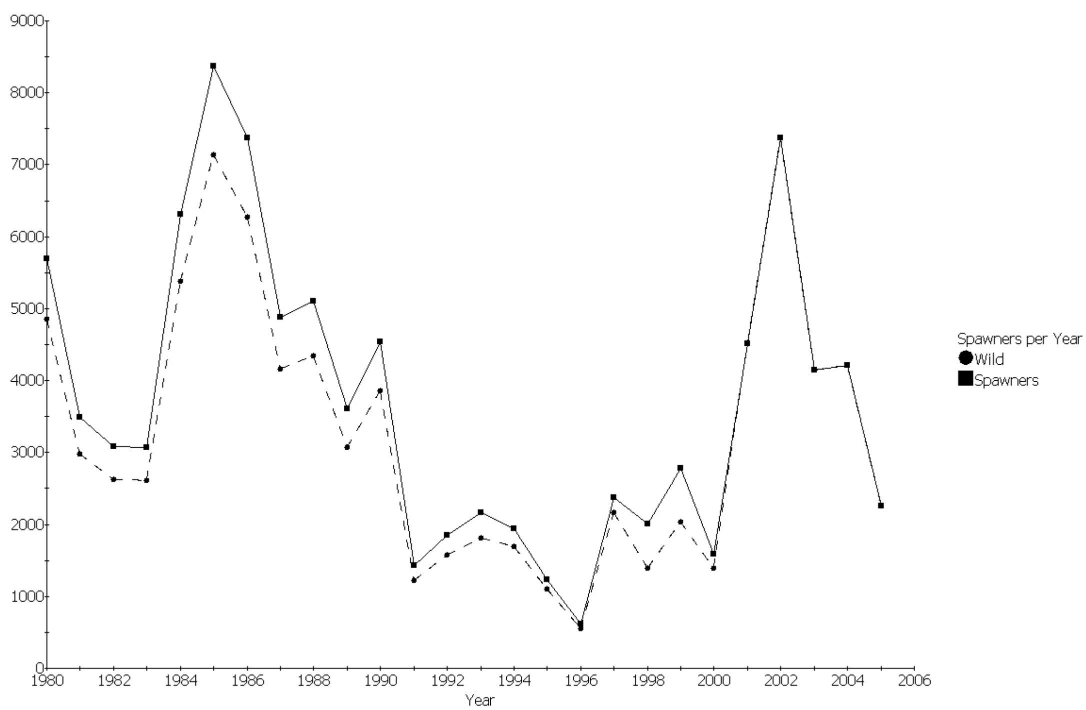

Figure 10: North Santiam River winter steelhead abundance.

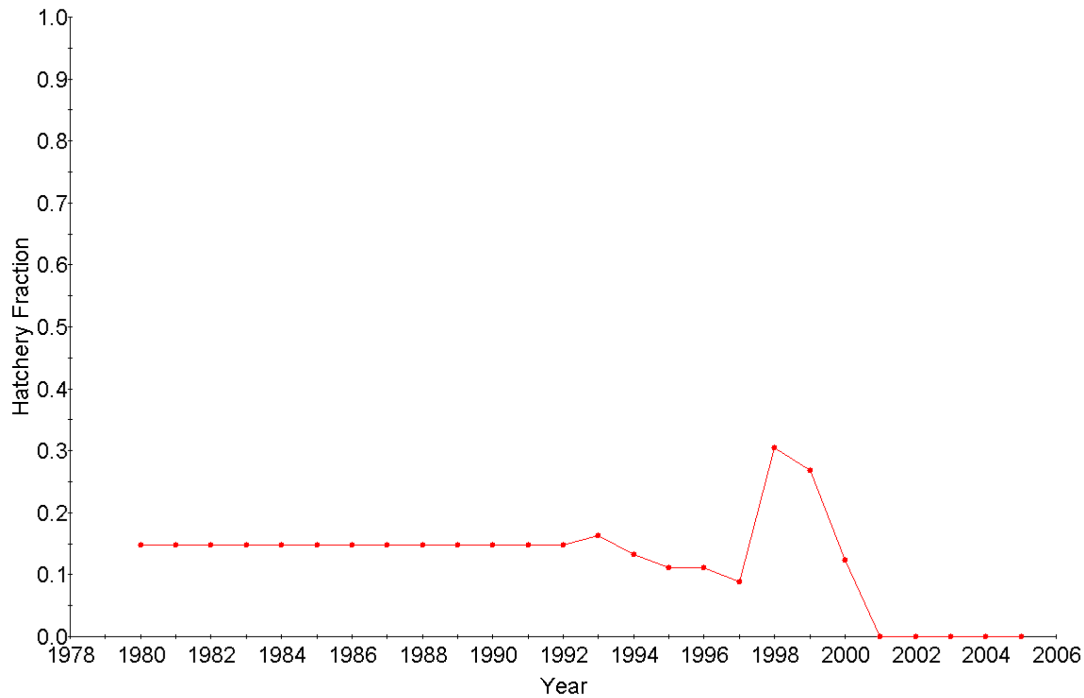

Figure 11: North Santiam River winter steelhead hatchery fraction.

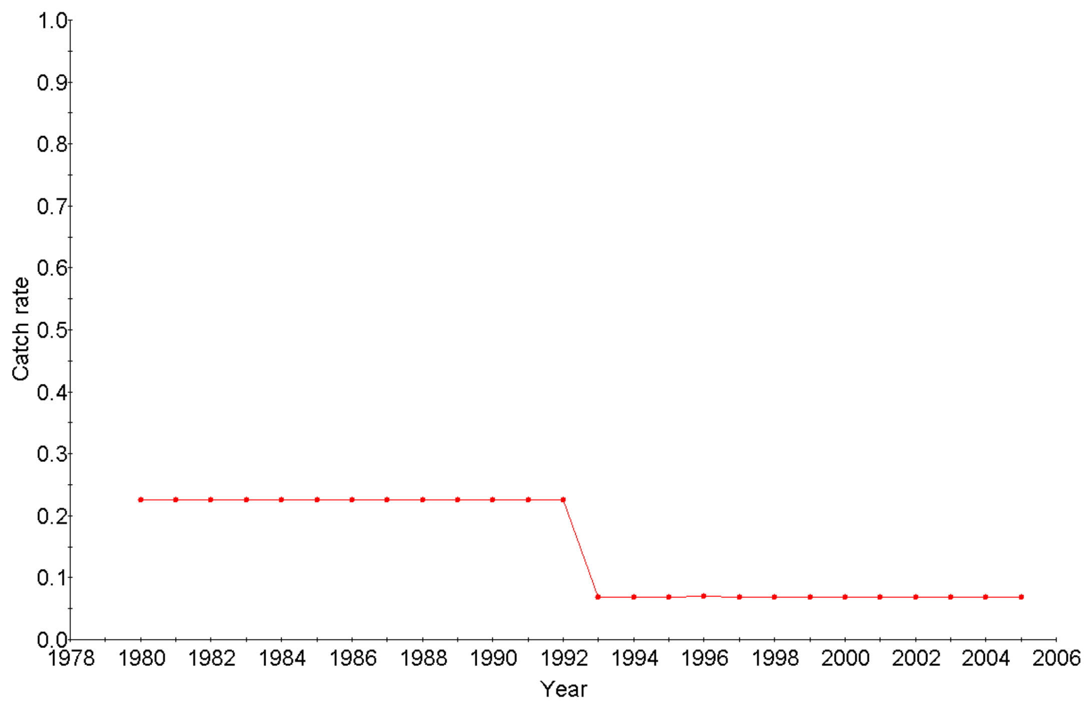

Figure 12: North Santiam River winter steelhead harvest rate.

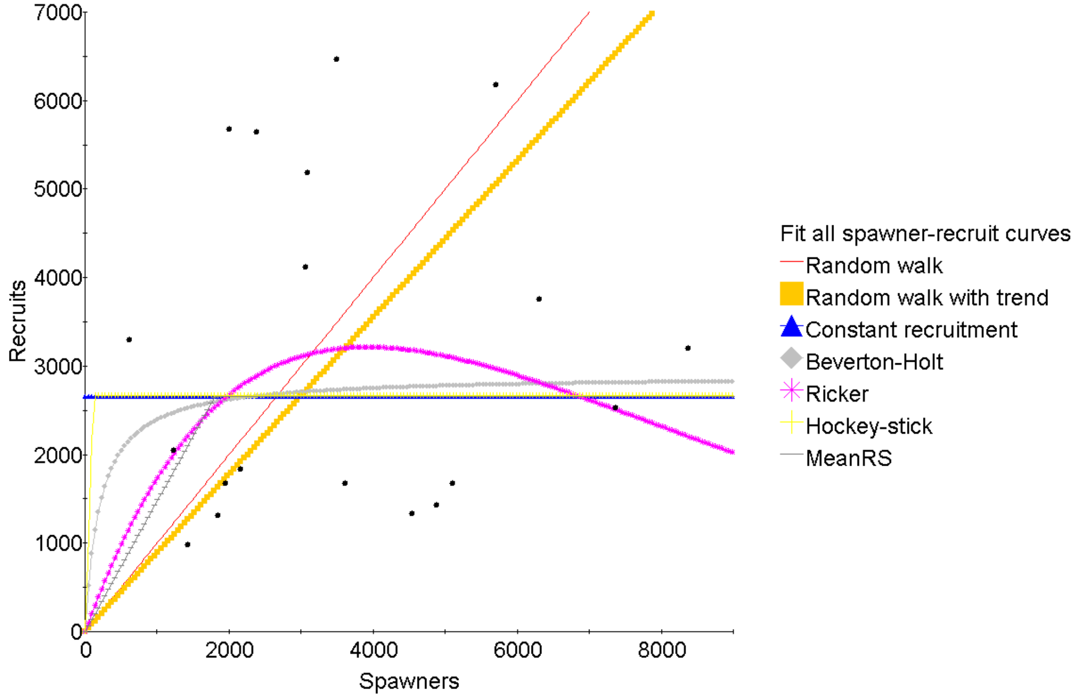

Figure 13: North Santiam River winter steelhead escapement recruitment functions.

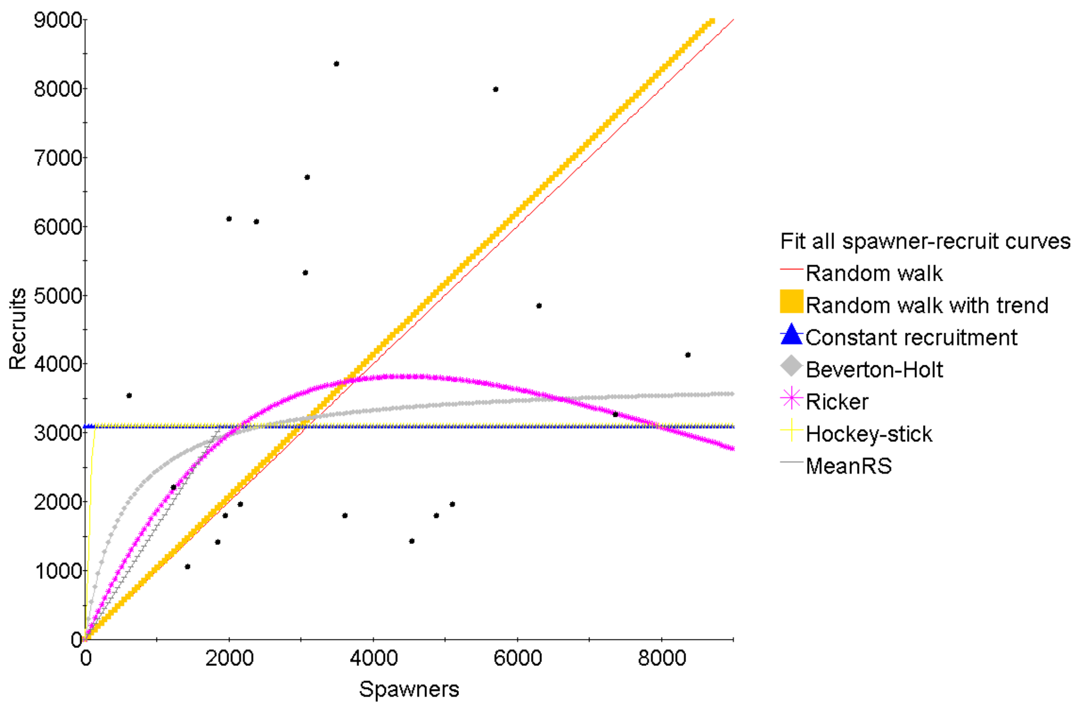

Figure 14: North Santiam River winter steelhead pre-harvest recruitment functions.

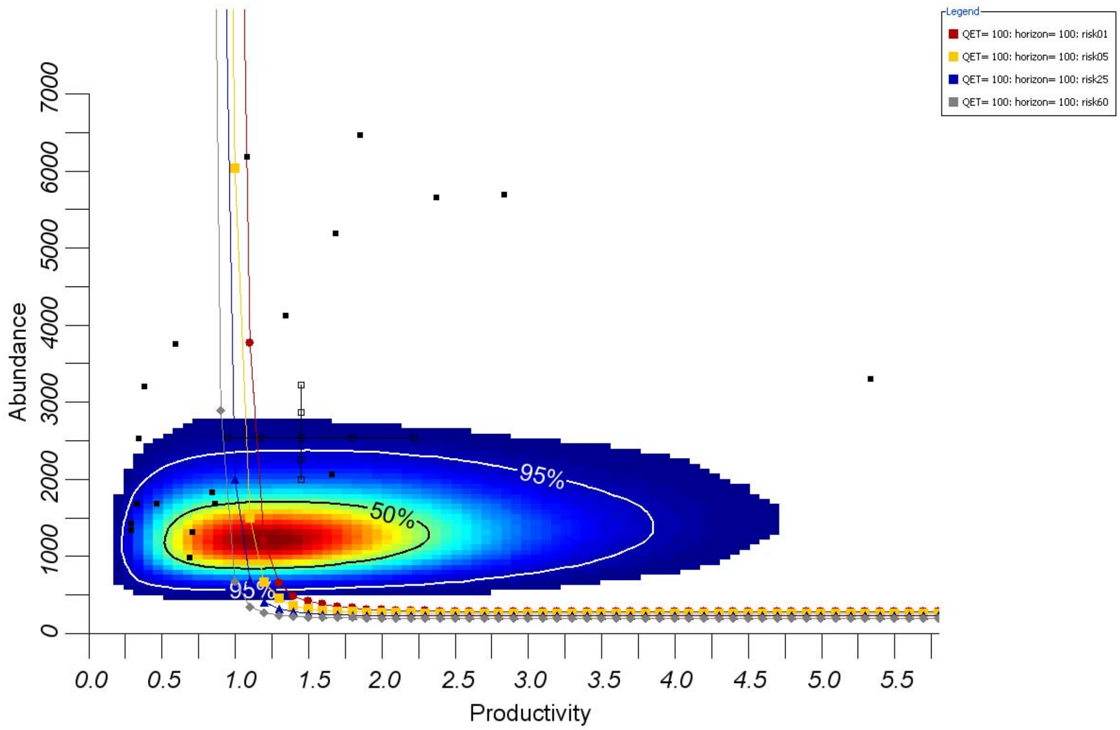

Figure 15: North Santiam River winter steelhead escapement viability curves.

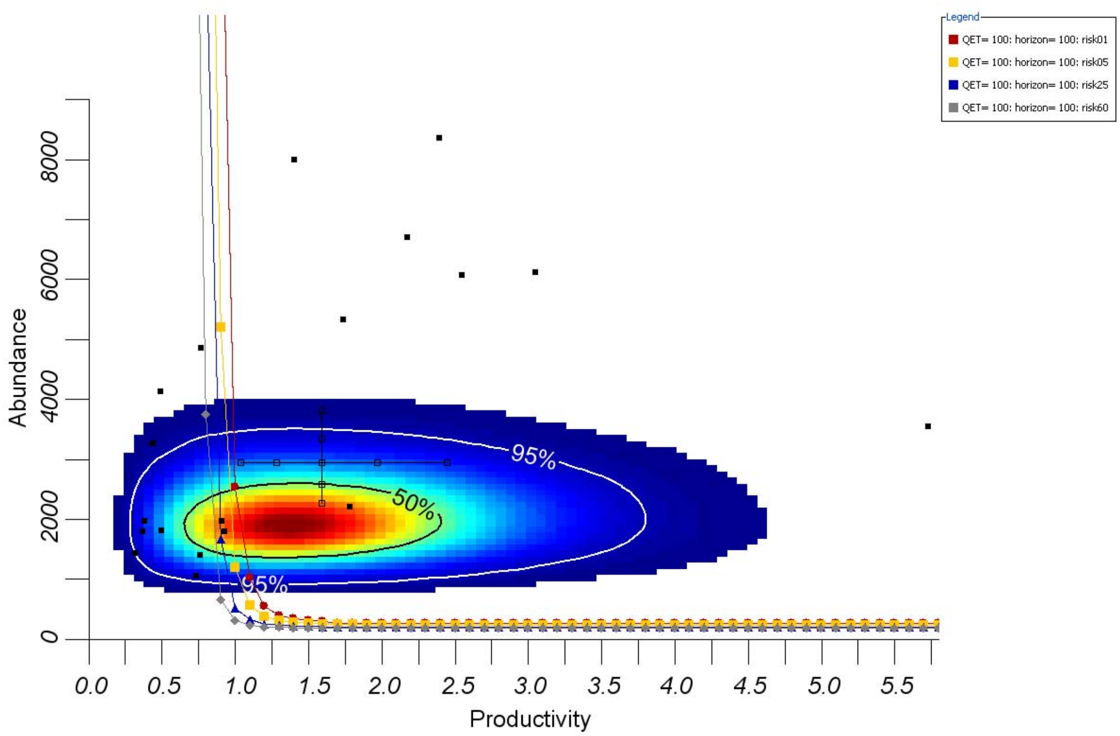

Figure 16: North Santiam River winter steelhead pre-harvest viability curves.

Table 5: North Santiam Winter Steelhead summary statistics. The geometric mean natural origin spawner abundance (highlighted) is in the "very low risk" viability criteria category. The 95% confidence intervals are shown in parentheses.

Statistic	Escapement		Pre-harvest	
	Total Series	Recent Years	Total Series	Recent Years
Time Series Period	1980-2005	1990-2005	1980-2005	1990-2005
Length of Time Series	26	16	26	16
Geometric Mean Natural Origin Spawner Abundance	2722 (2098-3531)	2109 (1485-2994)	NA	NA
Geometric Mean Recruit Abundance	2662 (1984-3571)	2187 (1341-3567)	3100 (2259-4256)	2350 (1441-3832)
Lambda	0.983 (0.786-1.231)	1.035 (0.705-1.519)	1.011 (0.81-1.262)	1.043 (0.696-1.562)
Trend in Log Abundance	0.98 (0.946-1.014)	1.065 (0.993-1.142)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.886 (0.59-1.331)	1.226 (0.619-2.429)	1.032 (0.692-1.539)	1.317 (0.665-2.609)
Geometric Mean Recruits per Spawner (broods < median spawner abudance)	1.474 (0.911-2.383)	1.368 (0.657-2.848)	1.642 (1.012-2.666)	1.47 (0.706-3.059)
Average Hatchery Fraction	0.124	0.109	NA	NA
Average Harvest Rate	0.147	0.098	NA	NA
CAPM median extinction risk probability (5th and 95th percentiles in parenthesis)	NA	NA	0.005 (0.000-0.075)	NA
PopCycle extinction risk	NA	NA	0.02	NA

Table 6: Escapement recruitment parameter estimates and relative AIC values for North Santiam winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.83 (0.68-1.18)	10.8
Random walk with trend	0.89 (0.66-1.33)	NA	0.82 (0.68-1.22)	12.4
Constant recruitment	NA	2658 (2120-3503)	0.59 (0.49-0.88)	0
Beverton-Holt	13.82 (3.19->30)	2898 (2298-4606)	0.59 (0.49-0.89)	1.8
Ricker	2.23 (1.24-4.06)	3213 (2716-5765)	0.62 (0.53-0.97)	3.7
Hockey-stick	23.56 (3.63->30)	2664 (2128-3521)	0.59 (0.49-0.88)	2
MeanRS	1.47 (1.07-2.07)	2662 (2130-3330)	0.43 (0.27-0.54)	13.5

Table 7: Pre-harvest recruitment parameter estimates and relative AIC values for North Santiam winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.81 (0.66-1.15)	6.9
Random walk with trend	1.03 (0.77-1.52)	NA	0.81 (0.67-1.2)	8.8
Constant recruitment	NA	3097 (2431-4192)	0.64 (0.53-0.95)	0
Beverton-Holt	6.96 (2.75->30)	3783 (2684-6085)	0.63 (0.53-0.94)	1.4
Ricker	2.34 (1.3-4.42)	3817 (3209-7548)	0.65 (0.56-1.01)	2.7
Hockey-stick	>30 (3.01->30)	3100 (2434-4290)	0.64 (0.53-0.96)	2
MeanRS	1.64 (1.18-2.3)	3100 (2430-3964)	0.47 (0.31-0.59)	10.4

Table 8: North Santiam winter steelhead SPMPC risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in "Extirpated or nearly so" category	0.782	0.851	1.000
Probability the population is above "Moderate risk of extinction" category	0.746	0.815	0.998
Probability the population is above "Viable" category	0.708	0.784	0.913
Probability the population is above "Very low risk of extinction" category	0.666	0.741	0.603

A&P – South Santiam

A time series of abundance sufficient for quantitative analysis is available for the South Santiam population (Appendix B). Descriptive graphs and viability analysis results are provided beginning with Figure 17 and in Table 9 and Table 12. The population is relatively large, with a long-term geometric mean natural origin spawner of 2,727 and a recent geometric mean of 2,302 (Table 9). These values are in the very low risk minimum abundance threshold (MAT) category.

The modeling results reflect the uncertainty in the input data and therefore in the population status. The pre-harvest viability curve analyses suggest that the population is probably viable if harvest levels remain low. The escapement viability curves suggest that the harvest pattern observed over the course of the time series is likely sustainable. Largely because of the high amount of measurement error in the input data, the "blobs" describing the current population status are relatively large and span all of the viability curve risk categories. This suggests caution in risk conclusions.

The CAPM analysis indicates that the population is viable as evidenced by a median value for predicted CRT probabilities of 0.005. The PopCycle analysis also suggests a very low risk (<0.01). We estimate that the population is most likely in the viable category, but the range of possibility spans the entire spectrum from very low risk to very high risk. The Oregon Native Fish Status report (ODFW 2005) gave this population a "pass" for abundance and productivity.

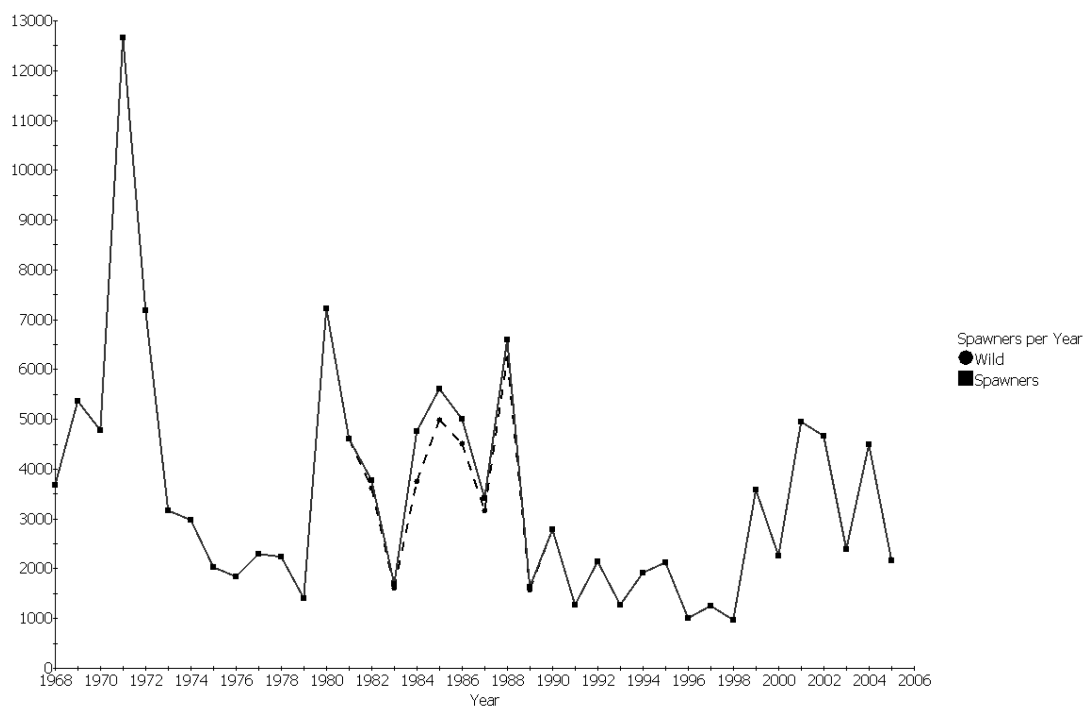

Figure 17: South Santiam Winter steelhead Abundance.

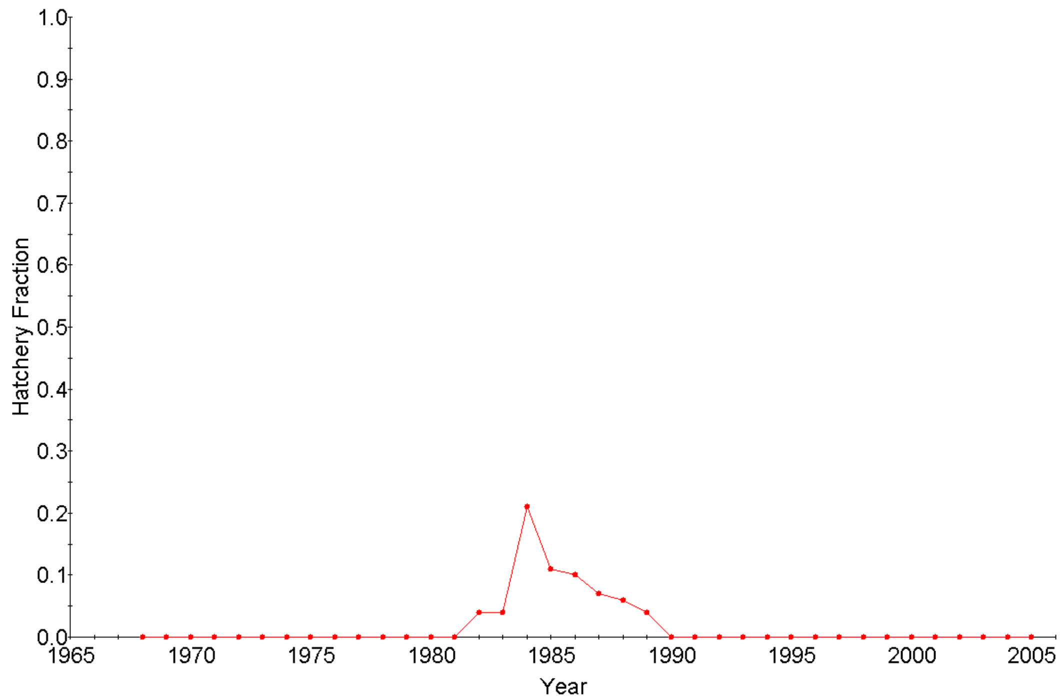

Figure 18: South Santiam River winter steelhead hatchery fraction.

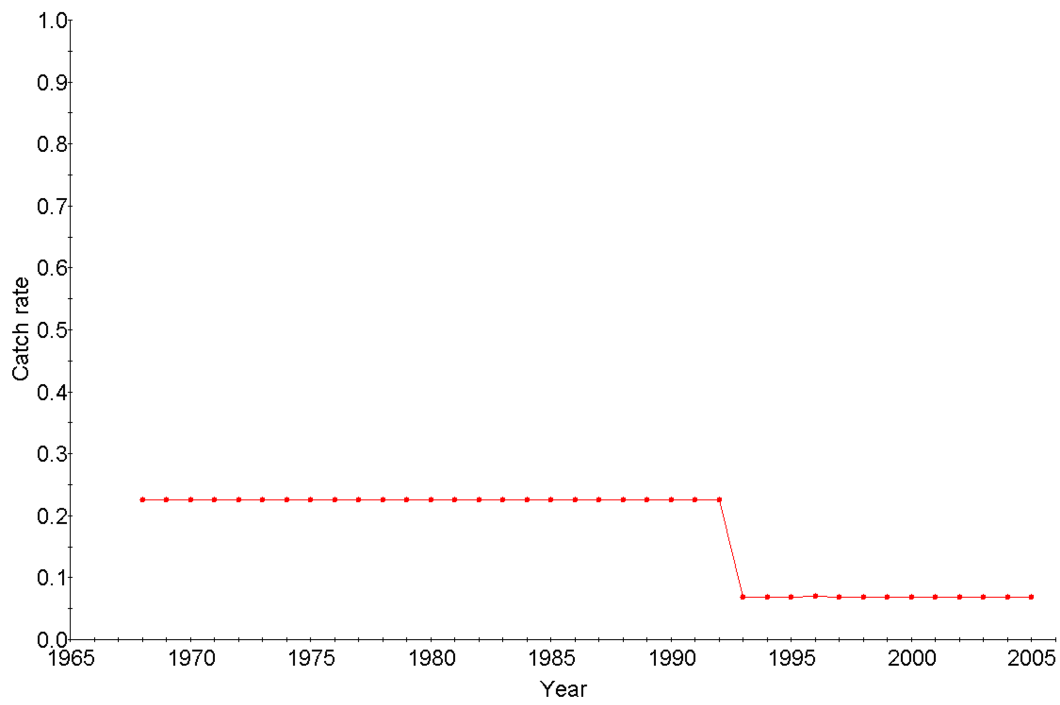

Figure 19: South Santiam River winter steelhead harvest rate.

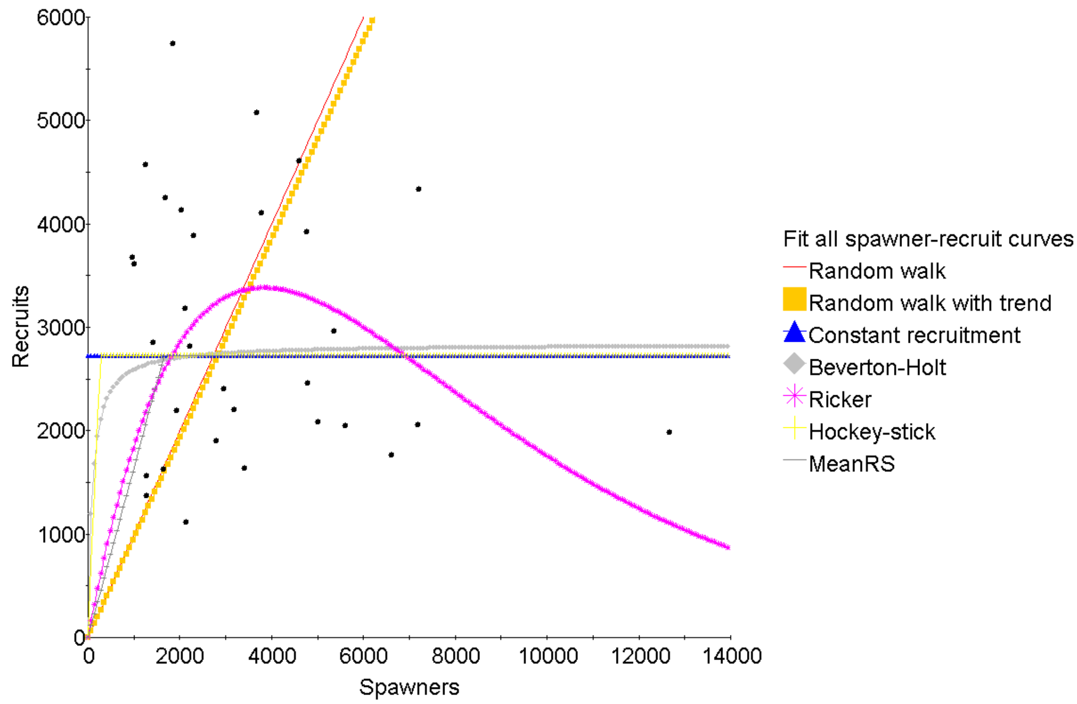

Figure 20: South Santiam River winter steelhead escapement recruitment functions.

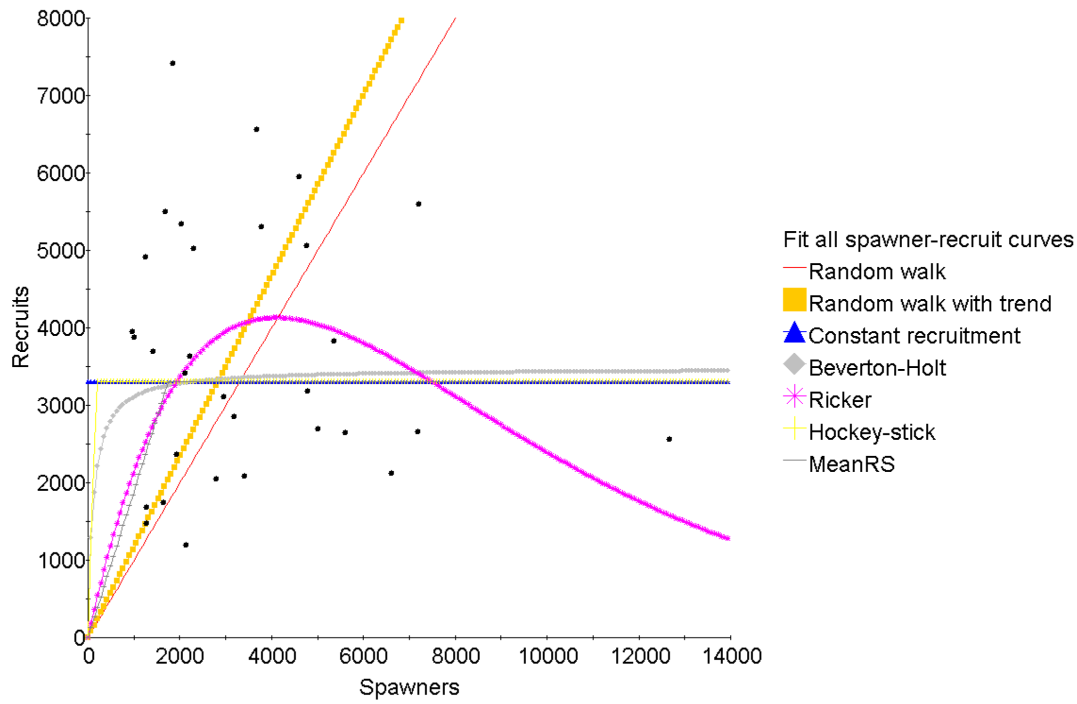

Figure 21: South Santiam River winter steelhead pre-harvest recruitment functions.

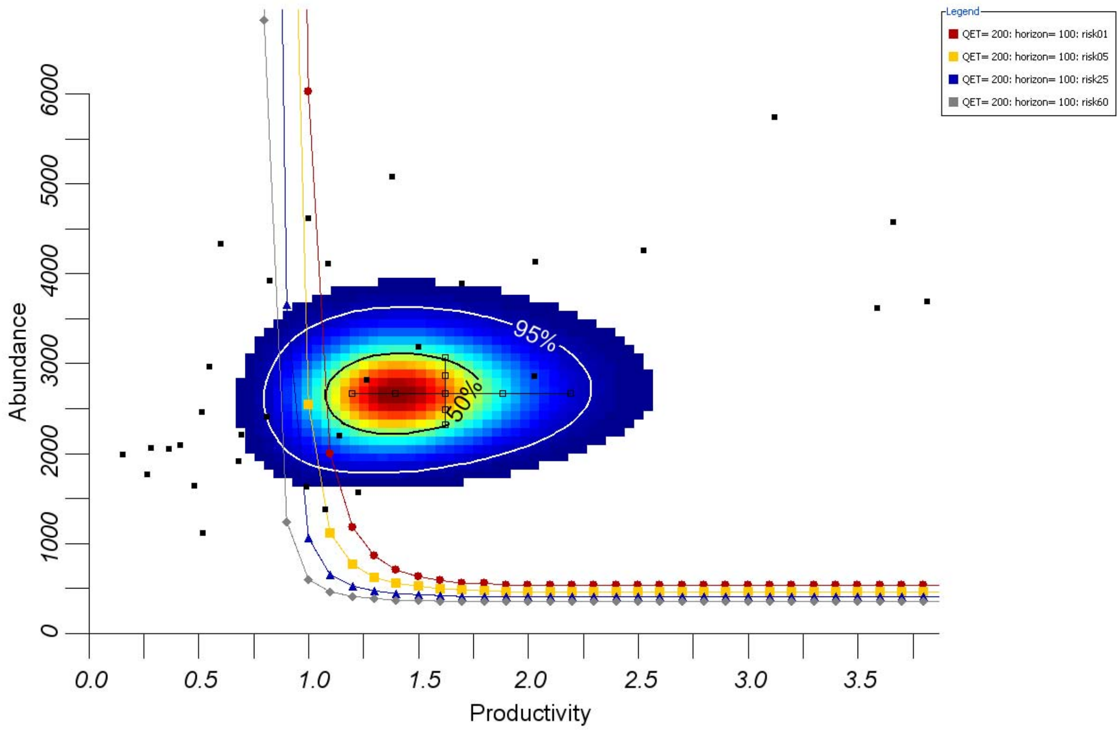

Figure 22: South Santiam River winter steelhead escapement viability curves.

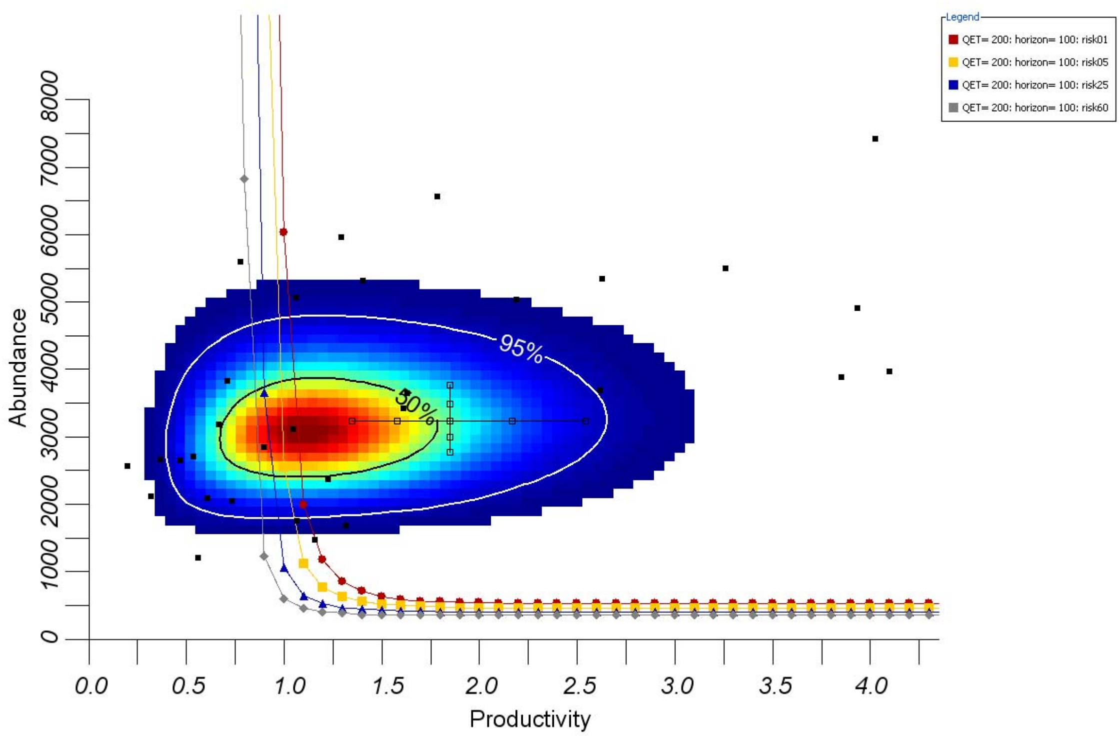

Figure 23: South Santiam River winter steelhead pre-harvest viability curves.

Table 9: South Santiam Winter Steelhead summary statistics. The geometric mean natural origin spawner abundance (highlighted) is in the "very low risk" viability criteria category. The 95% confidence intervals are shown in parentheses.

Statistic	Escapement		Pre-harvest	
	Total Series	Recent Years	Total Series	Recent Years
Time Series Period	1968-2005	1990-2005	1968-2005	1990-2005
Length of Time Series	38	16	38	16
Geometric Mean Natural Origin Spawner Abundance	2862 (2350-3486)	2149 (1618-2853)	NA	NA
Geometric Mean Recruit Abundance	2727 (2328-3194)	2320 (1584-3399)	3309 (2786-3930)	2492 (1701-3651)
Lambda	0.976 (0.855-1.114)	1.052 (0.773-1.43)	1.014 (0.892-1.152)	1.06 (0.764-1.471)
Trend in Log Abundance	0.981 (0.965-0.998)	1.054 (0.997-1.115)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.962 (0.714-1.295)	1.509 (0.854-2.666)	1.167 (0.873-1.559)	1.621 (0.917-2.864)
Geometric Mean Recruits per Spawner (broods < median spawner abudance)	1.643 (1.191-2.266)	1.666 (0.908-3.055)	NA	NA
Average Hatchery Fraction	0.018	0	NA	NA
Average Harvest Rate	0.172	0.098	0.172	0.098
CAPM median extinction risk probability (5th and 95th percentiles in parenthesis)	NA	NA	0.005 (0.000-0.030)	NA
PopCycle extinction risk	NA	NA	0.02	NA

Table 10: Escapement recruitment parameter estimates and relative AIC values for South Santiam winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.8 (0.67-1.03)	37.4
Random walk with trend	0.96 (0.77-1.27)	NA	0.8 (0.68-1.06)	39.3
Constant recruitment	NA	2727 (2400-3140)	0.42 (0.36-0.56)	0
Beverton-Holt	>30 (7.01->30)	2839 (2540-3507)	0.42 (0.37-0.57)	2.3
Ricker	2.41 (1.86-3.18)	3381 (2988-4079)	0.47 (0.41-0.64)	8.2
Hockey-stick	10.21 (3.59->30)	2725 (2399-3132)	0.42 (0.36-0.56)	2
MeanRS	1.64 (1.29-2.09)	2727 (2401-3087)	0.22 (0.15-0.27)	71

Table 11: Pre-harvest recruitment parameter estimates and relative AIC values for North Santiam winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.79 (0.67-1.02)	31.5
Random walk with trend	1.17 (0.93-1.52)	NA	0.78 (0.66-1.03)	32.3
Constant recruitment	NA	3308 (2882-3863)	0.46 (0.39-0.61)	0
Beverton-Holt	>30 (6.18->30)	3477 (3105-4578)	0.46 (0.39-0.61)	1.9
Ricker	2.74 (2.1-3.66)	4130 (3632-5076)	0.49 (0.42-0.66)	5.4
Hockey-stick	18.13 (3.77->30)	3307 (2884-3856)	0.46 (0.39-0.61)	2
MeanRS	1.89 (1.47-2.43)	3309 (2884-3784)	0.24 (0.17-0.31)	59.3

Table 12: North Santiam winter steelhead CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in "Extirpated or nearly so" category	0.988	0.835	1.000
Probability the population is above "Moderate risk of extinction" category	0.975	0.794	0.997
Probability the population is above "Viable" category	0.956	0.751	0.960
Probability the population is above "Very low risk of extinction" category	0.913	0.678	0.637

A&P – Calapooia

A time series of abundance sufficient for quantitative analysis is available for the Calapooia population (Appendix B). Descriptive graphs and viability analysis results are provided beginning with Figure 24 and in Table 13 and Table 16. The population is small, with a long-term geometric mean natural origin spawner of 458 and a recent geometric mean of 339 (Table 9). These values are in the moderate risk minimum abundance threshold (MAT) category.

The modeling results reflect the uncertainty in the input data and therefore in the population status. The pre-harvest viability curve analyses suggest that the population is probably viable if harvest levels remain low. The escapement viability curves suggest that the harvest pattern observed over the course of the time series is likely sustainable. Largely because of the high amount of measurement error in the input data, the “blobs” describing the current population status are relatively large and span all of the viability curve risk categories. This suggests caution in risk conclusions.

The PopCycle modeling and the CAPM analysis indicates that the population is not viable and the predicted quasi-extinction probability over 100 years is 20% for PopCycle, and around 22% for CAPM. We estimate that the population is most likely in in the “moderate risk” category, but the range of possibility spans the entire spectrum from very low risk to very high risk. The Oregon Native Fish Status report (ODFW 2005) gave this population a “pass” for abundance and productivity.

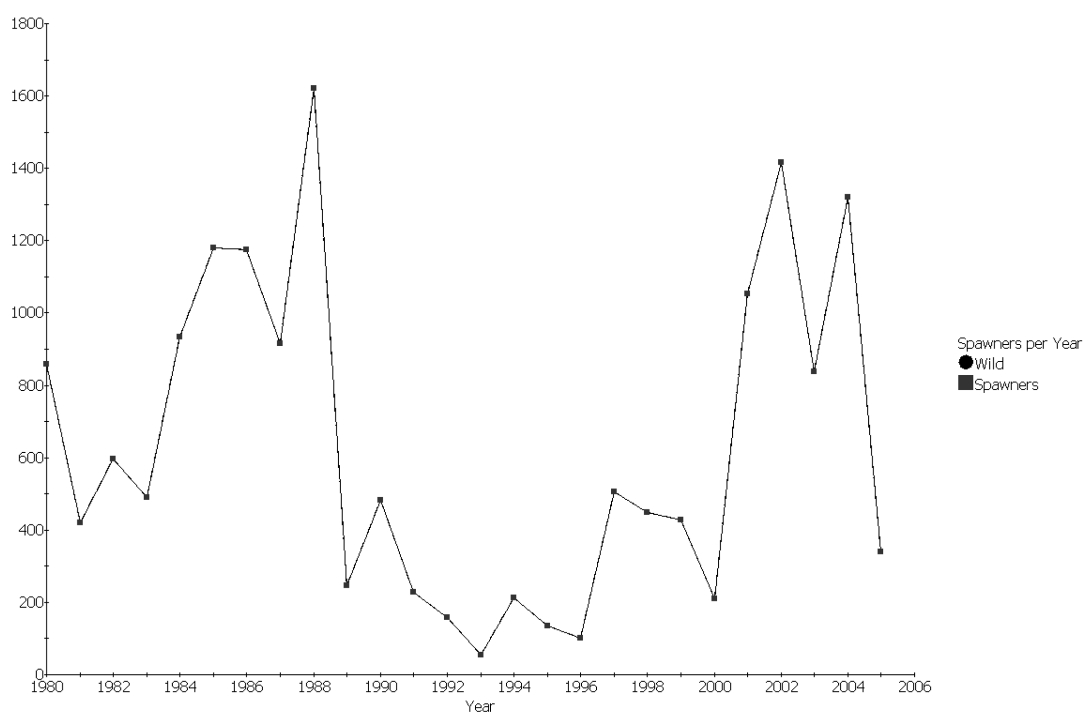

Figure 24: Calapooia River winter steelhead abundance.

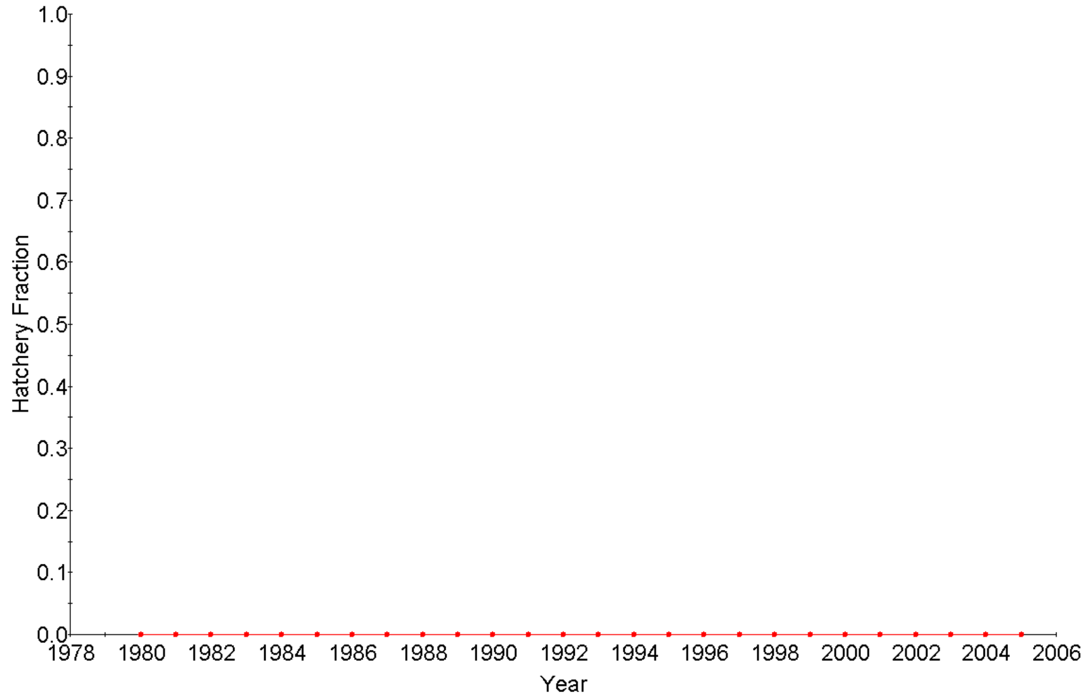

Figure 25: Calapooia River winter steelhead hatchery fraction.

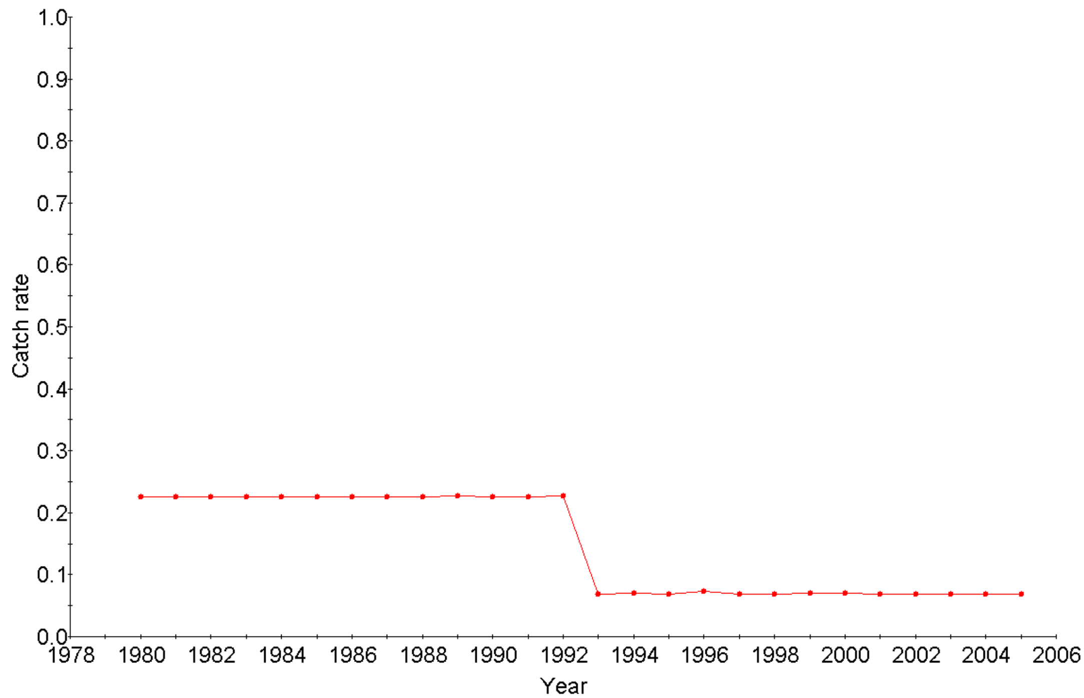

Figure 26: Calapooia River winter steelhead harvest rate.

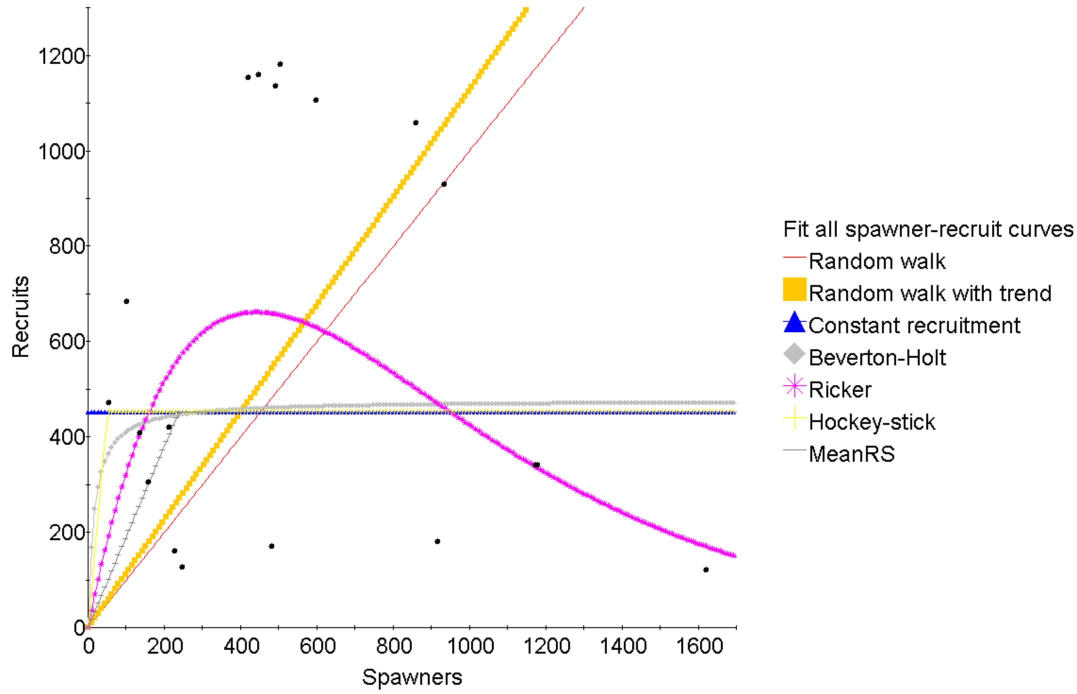

Figure 27: Calapooia River winter steelhead escapement recruitment functions.

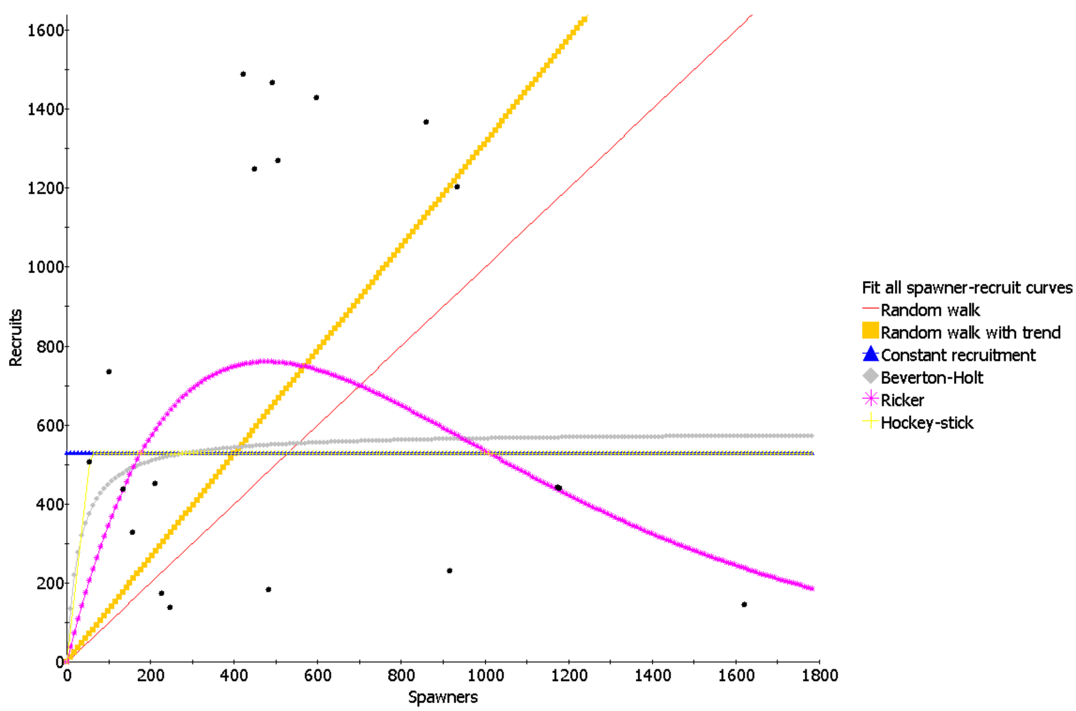

Figure 28: Calapooia River winter steelhead pre-harvest recruitment functions.

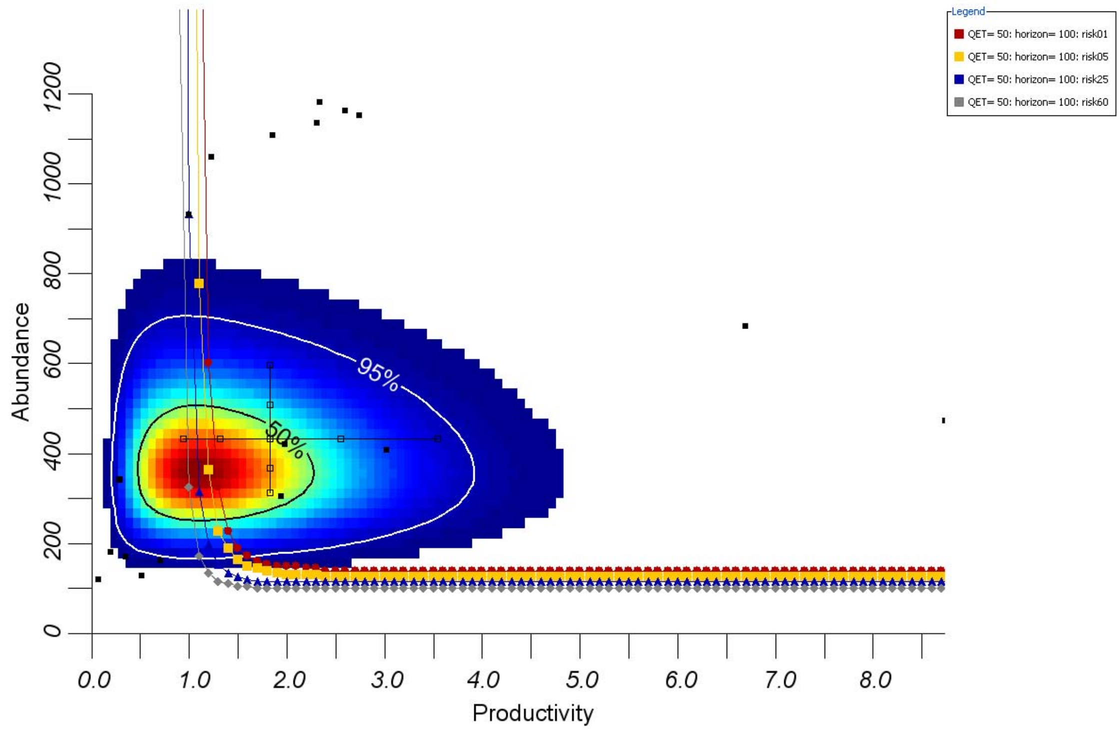

Figure 29: Calapooia River winter steelhead escapement viability curves.

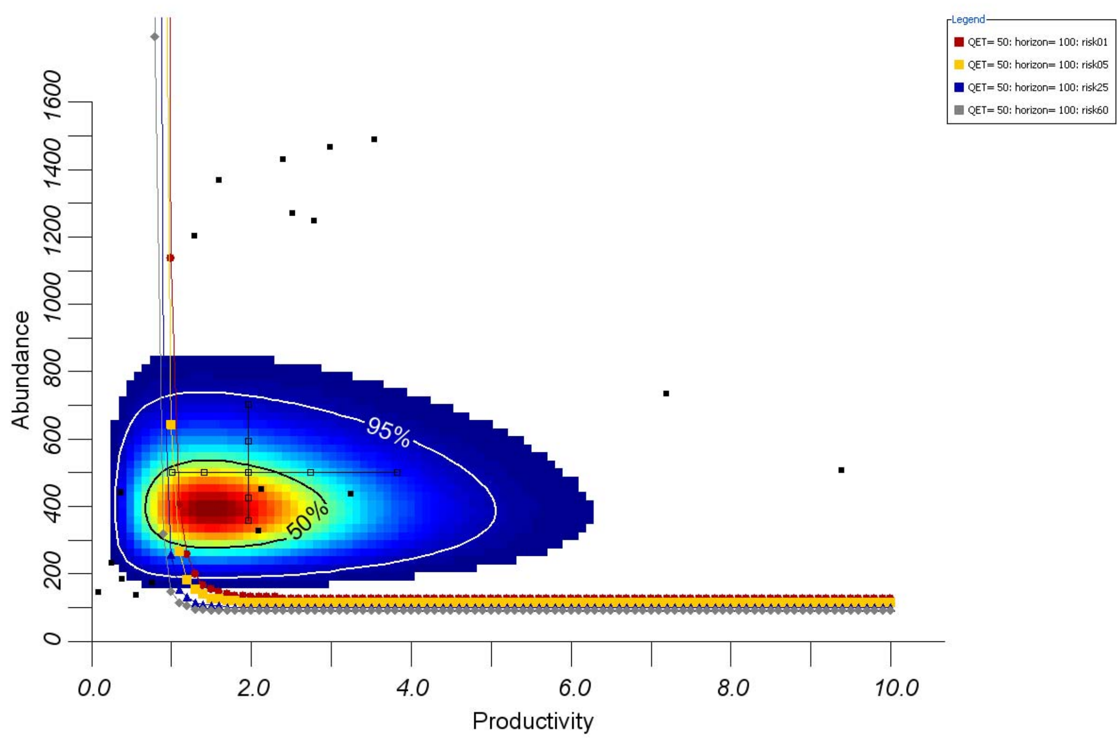

Figure 30: Calapooia River winter steelhead pre-harvest viability curves.

Table 13: Calapooia Winter Steelhead summary statistics. The geometric mean natural origin spawner abundance (highlighted in yellow) is in the "moderate risk" viability criteria category. The 95% confidence intervals are shown in parentheses.

Statistic	Escapement		Pre-harvest	
	Total Series	Recent Years	Total Series	Recent Years
Time Series Period	1980-2005	1990-2005	1980-2005	1990-2005
Length of Time Series	26	16	26	16
Geometric Mean Natural Origin Spawner Abundance	458 (319-657)	339 (206-560)	NA	NA
Geometric Mean Recruit Abundance	453 (304-675)	441 (253-769)	529 (350-799)	474 (272-826)
Lambda	1.023 (0.743-1.409)	1.128 (0.959-1.328)	1.053 (0.772-1.436)	1.136 (0.941-1.372)
Trend in Log Abundance	0.987 (0.94-1.037)	1.13 (1.035-1.235)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	1.126 (0.617-2.055)	2.163 (1.007-4.646)	1.315 (0.731-2.365)	2.324 (1.082-4.99)
Geometric Mean Recruits per Spawner (broods < median spawner abudance)	1.905 (0.901-4.024)	2.799 (1.069-7.329)	2.084 (0.981-4.43)	3.007 (1.149-7.872)
Average Hatchery Fraction	0.000	0.000	NA	NA
Average Harvest Rate	0.148	0.099	NA	NA
CAPM median extinction risk probability (5th and 95th percentiles in parenthesis)	NA	NA	0.22	NA
PopCycle extinction risk	NA	NA	0.20	NA

Table 14: Escapement recruitment parameter estimates and relative AIC values for Calapooia winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.22 (0.99-1.73)	14.3
Random walk with trend	1.13 (0.75-2.09)	NA	1.21 (1.01-1.81)	16.1
Constant recruitment	NA	453 (338-670)	0.8 (0.67-1.19)	0.5
Beverton-Holt	>30 (4.53->30)	477 (370-886)	0.8 (0.68-1.21)	2.5
Ricker	4.05 (2.44-8.07)	661 (527-1103)	0.76 (0.64-1.21)	0
Hockey-stick	9.01 (4.46->30)	452 (337-676)	0.8 (0.67-1.2)	2.5
MeanRS	1.9 (1.13-3.17)	453 (332-613)	0.85 (0.53-1.08)	7.6

Table 15: Pre-harvest recruitment parameter estimates and relative AIC values for Calapooia winter steelhead. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.22 (0.99-1.73)	12.8
Random walk with trend	1.31 (0.88-2.4)	NA	1.18 (0.99-1.76)	13.8
Constant recruitment	NA	529 (392-802)	0.83 (0.69-1.23)	0.4
Beverton-Holt	25.19 (4.2-28.6)	574 (438-1169)	0.83 (0.7-1.26)	2.3
Ricker	4.33 (2.55-9.17)	756 (607-1348)	0.78 (0.67-1.26)	0
Hockey-stick	9.38 (4.21-28.65)	533 (390-817)	0.84 (0.7-1.25)	2.4
MeanRS	2.08 (1.22-3.5)	529 (384-721)	0.87 (0.53-1.11)	6.8

Table 16: Calapooia winter steelhead CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in "Extirpated or nearly so" category	0.744	0.895	0.997
Probability the population is above "Moderate risk of extinction" category	0.692	0.880	0.817
Probability the population is above "Viable" category	0.630	0.849	0.072
Probability the population is above "Very low risk of extinction" category	0.590	0.824	0.003

A&P – Criterion Summary

The most probable risk classification was 'moderate' risk for the Molalla and Calapooia populations and 'low' risk for the North and South Santiam populations. However, as illustrated in Figure 31 by the tall aspect of the diamond symbols, the evaluation results for UW steelhead populations reflect a high degree of uncertainty. Because of this assessment uncertainty, the possible (not probable) risk classifications range from very low to very high for all four populations. In light of this and the most probable classification results, we conclude that overall, these population results place the ESU in the 'moderate' risk category with respect to the A&P criterion.

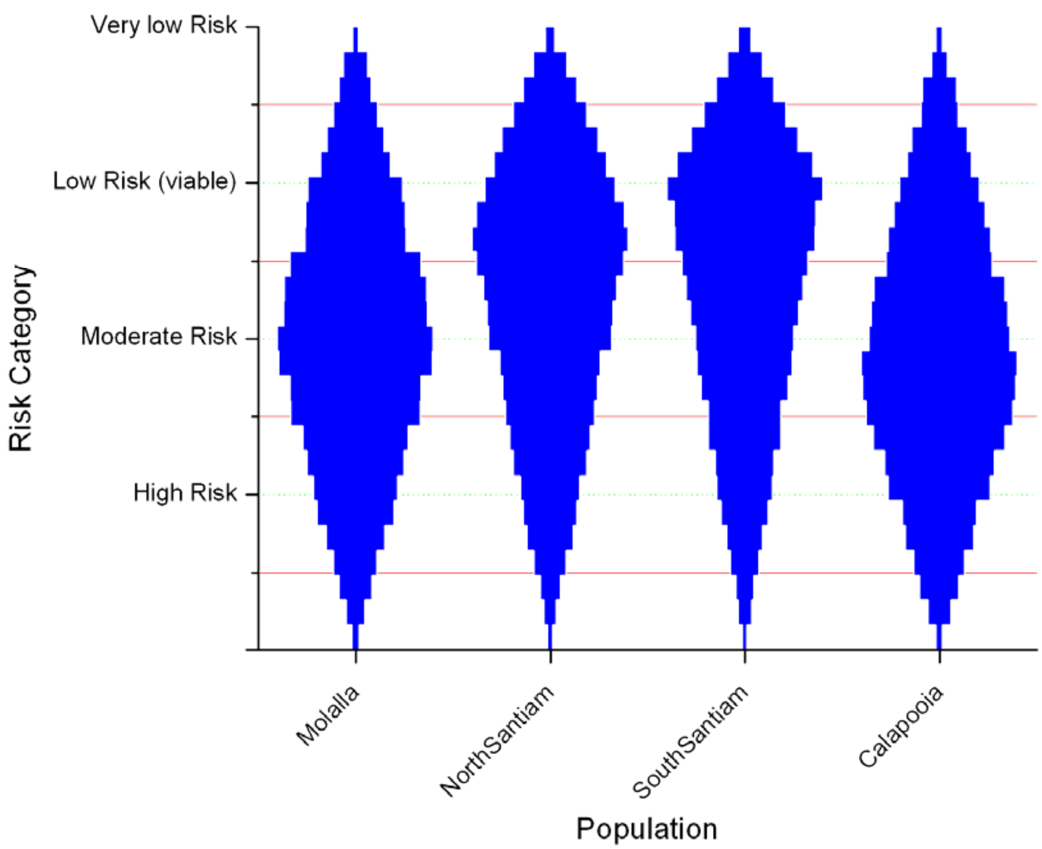

Figure 31: Graph of abundance and productivity risk estimate for Upper Willamette Steelhead.

III. Spatial Structure

SS – Molalla

Land use and road building has limited access of anadromous fish to many higher order tributaries in the Molalla and Pudding rivers but no large mainstem fish barriers are present. On a stream mile basis this impairment is significant (Figure 32). However, small high order streams that comprise most of the blocked area were not highly productive winter steelhead habitats. ODFW (2005) reports that virtually all of the historically significant steelhead habitat remains accessible. Habitat degradation due to land use has reduced water quality and the availability of suitable rearing habitat for steelhead in the Molalla River.

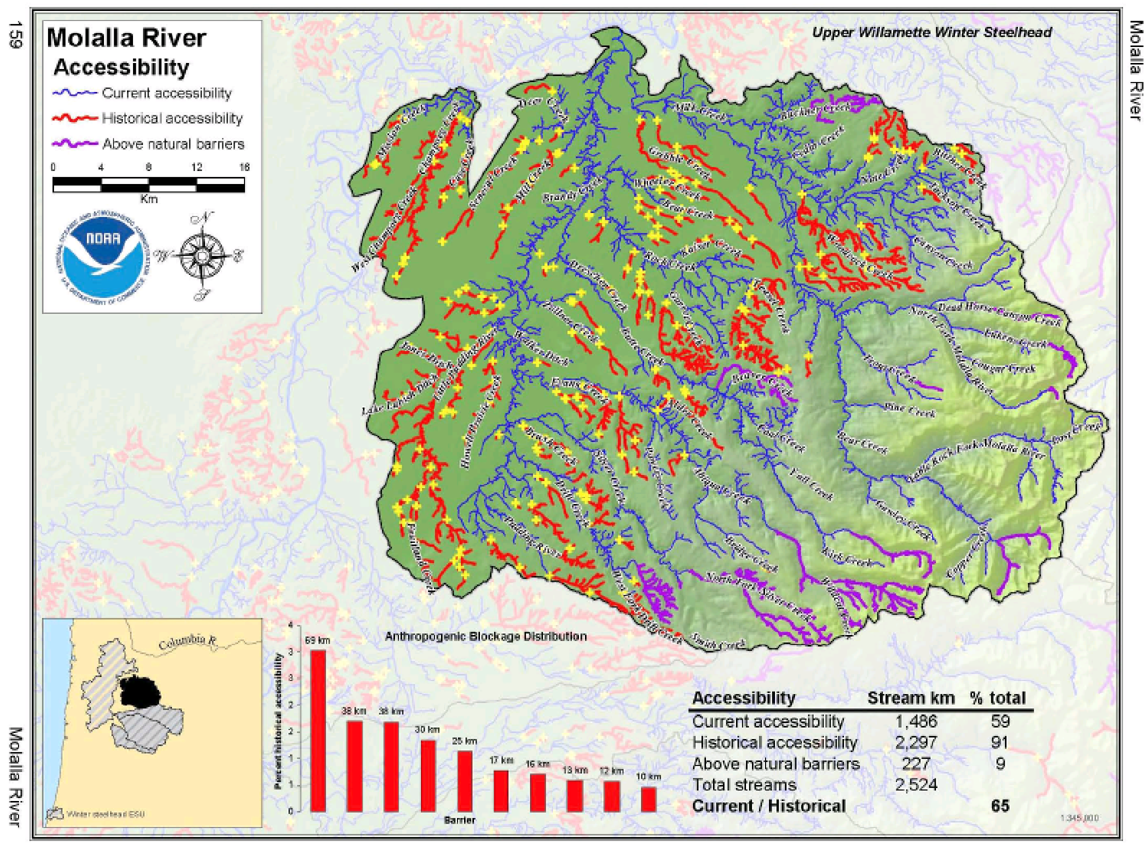

Figure 32: Molalla River winter steelhead current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – North Santiam

Access to large portions of historically productive steelhead habitat has been blocked by Detroit Reservoir (Figure 33). ODFW estimates that 46% of the historically suitable habitat for steelhead is now inaccessible (ODFW 2005).The blocked areas historically included some of the most productive habitats in this system although productive habitat remains in the Little North Santiam River. The watershed score for spatial structure was further reduced to account for habitat declines in the remaining accessible habitat.

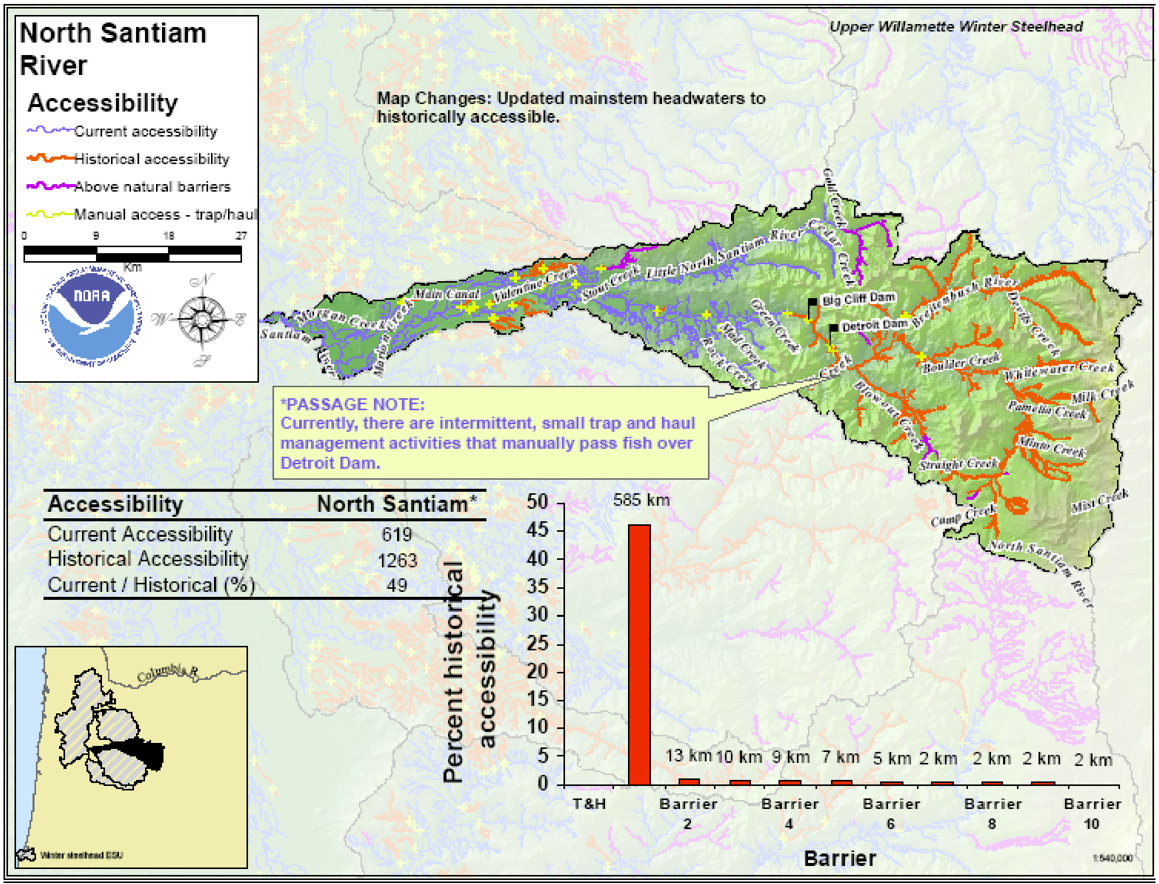

Figure 33: North Santiam River winter steelhead current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – South Santiam

Access to the upper South Santiam has been blocked by Foster and Green Peter Dams although significant steelhead habitat remains in other portions of this system (Figure 34). In the case of Foster Dam, a trap and haul program is currently moving fish upstream of this blockage. There is no passage of steelhead above Green Peter Dam and so the historical production area upstream of this dam is no longer accessible. ODFW (2005) estimates that 17% of the historically suitable habitat for steelhead is now inaccessible. Access has also been impaired in the upper reaches of many small low-elevation tributaries although these areas likely did not historically support high densities of steelhead. Habitat degradation due to land use and flow regulation has reduced water quality and the availability of suitable rearing habitat for steelhead in the South Santiam River.

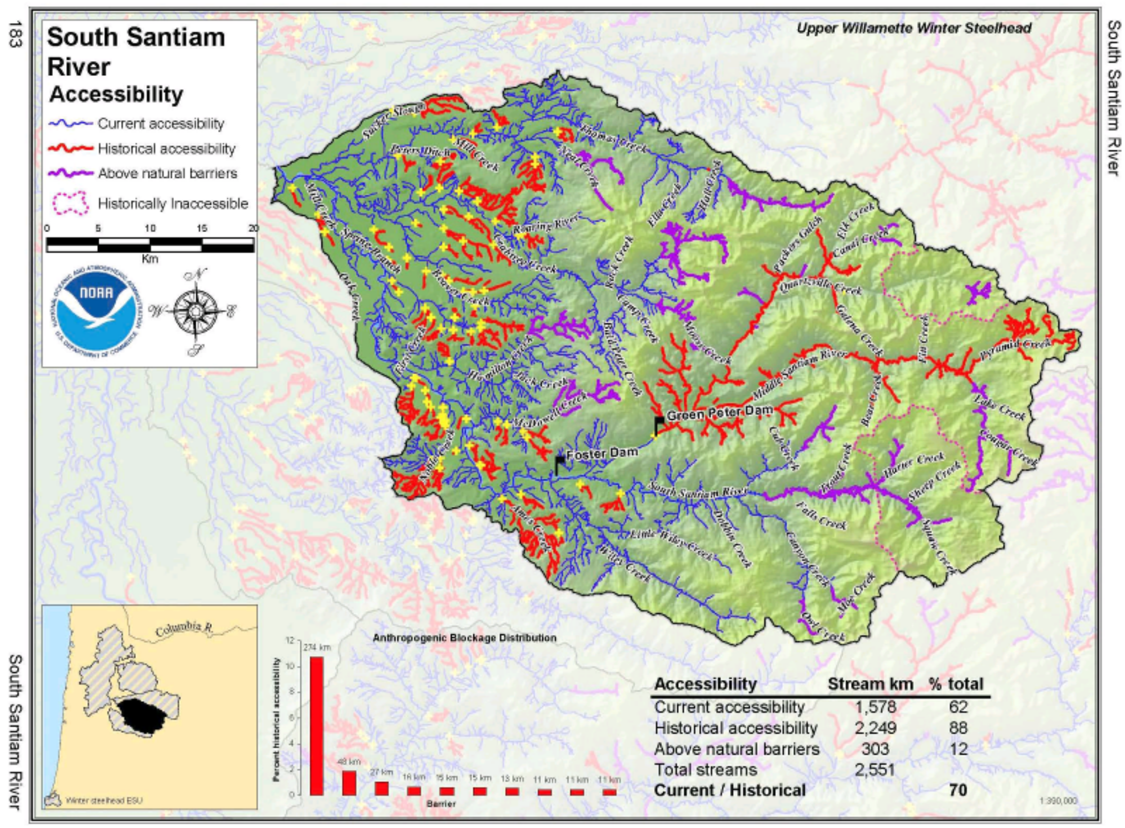

Figure 34: South Santiam River winter steelhead current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Calapooia

Steelhead returning to the Calapooia basin do not have accessibility to potential production areas that they had historically. (Figure 35). In addition, habitat degradation has substantially reduced the spatial distribution of suitable steelhead habitat within the accessible area. However, some of the blocked habitat may not have been historically used by winter steelhead.

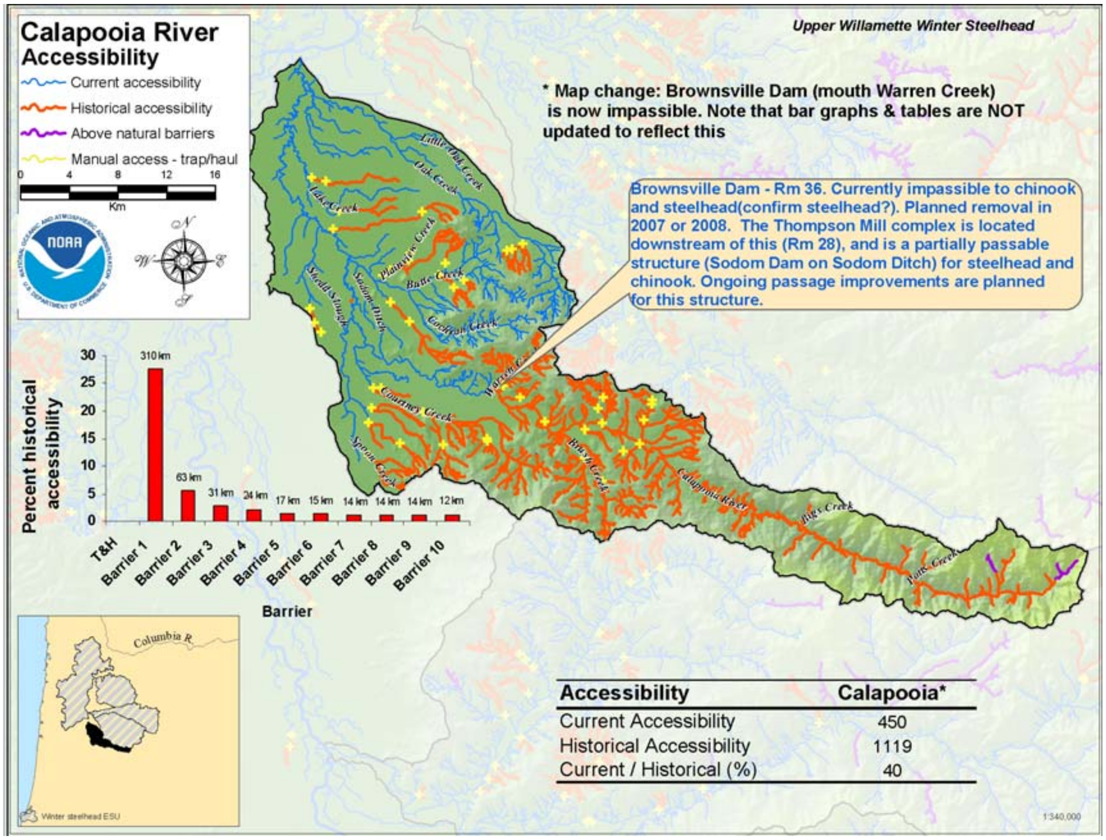

Figure 35: Calapooia River winter steelhead current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use. NOTE: This map incorrectly indicates that steelhead are blocked by Brownsville Dam on the mainstem Calapooia. Although the dam is a barrier for spring Chinook, it is generally considered passable by steelhead.

SS – Criterion Summary

The percentage of historically accessible habitat lost due to human activities exceeds 30% for all of the populations within this ESU (Figure 36). SS scores for each population were adjusted, where applicable, on the basis of two factors: 1) the suitability/quality of the blocked habitat with respect to Chinook production and 2) the degree to which the remaining accessible habitat has been degraded from historical conditions. The adjustments and final SS scores for each population are presented in Table 18.

For the SS criterion the most probable risk category for three of the four populations is either 'moderate' or 'high' (Figure 37). Only the Molalla population received a most probable risk classification of 'low'. Although there is a degree of uncertainty associated with these scores, overall we conclude that the most probable risk classification for these populations (and ESU) with respect to the SS criterion is 'moderate'.

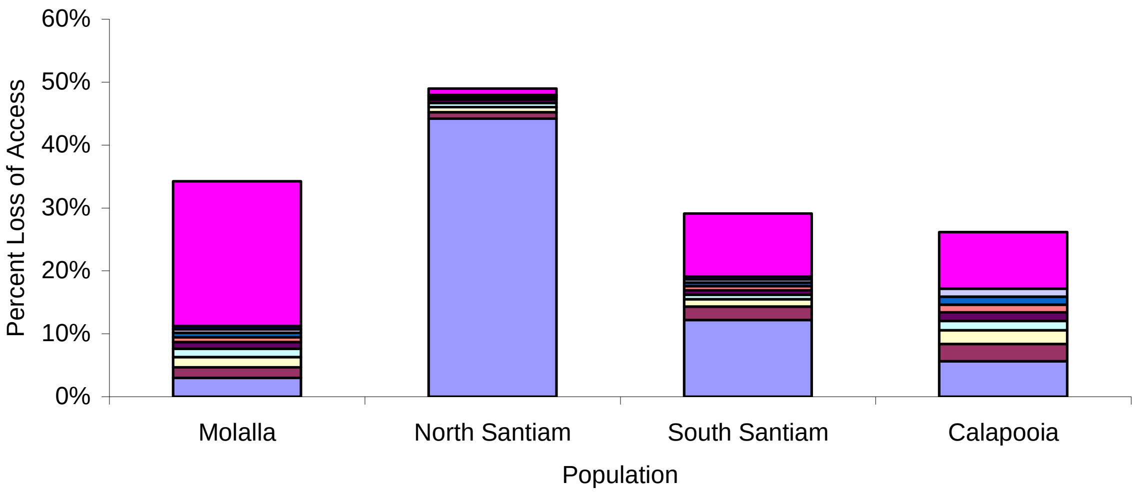

Figure 36: Percent loss in Upper Willamette winter steelhead accessibility due to anthropogenic blockages (based on Maher et al. 2005). Each color represents a blockage ordered from largest to smallest (bottom-up). The topmost blockages (i.e., the pink segment of the Calapooia bar) represent a collection of many smaller blockages. Note that in the Upper Willamette winter steelhead some of these pools of smaller blockages represent a larger percent loss of access than the largest blockage in that same population. The figure considers Brownsville Dam in the Calapooia passable for steelhead (i.e., it does NOT match the map in Figure 35).

Table 17: UW steelhead spatial structure scores.

Population	Base Access Score	Adjustment for Large Single Blockage	Adjusted Access Score	SS Rating Considering: Access Score, Historical Use Distribution, and Habitat Degradation	Confidence in SS rating
Molalla	2	no	2	3	M
North Santiam	1	yes	0.5	1	M
South Santiam	2	no	2	2	L
Calapooia	1	no	1	1	M

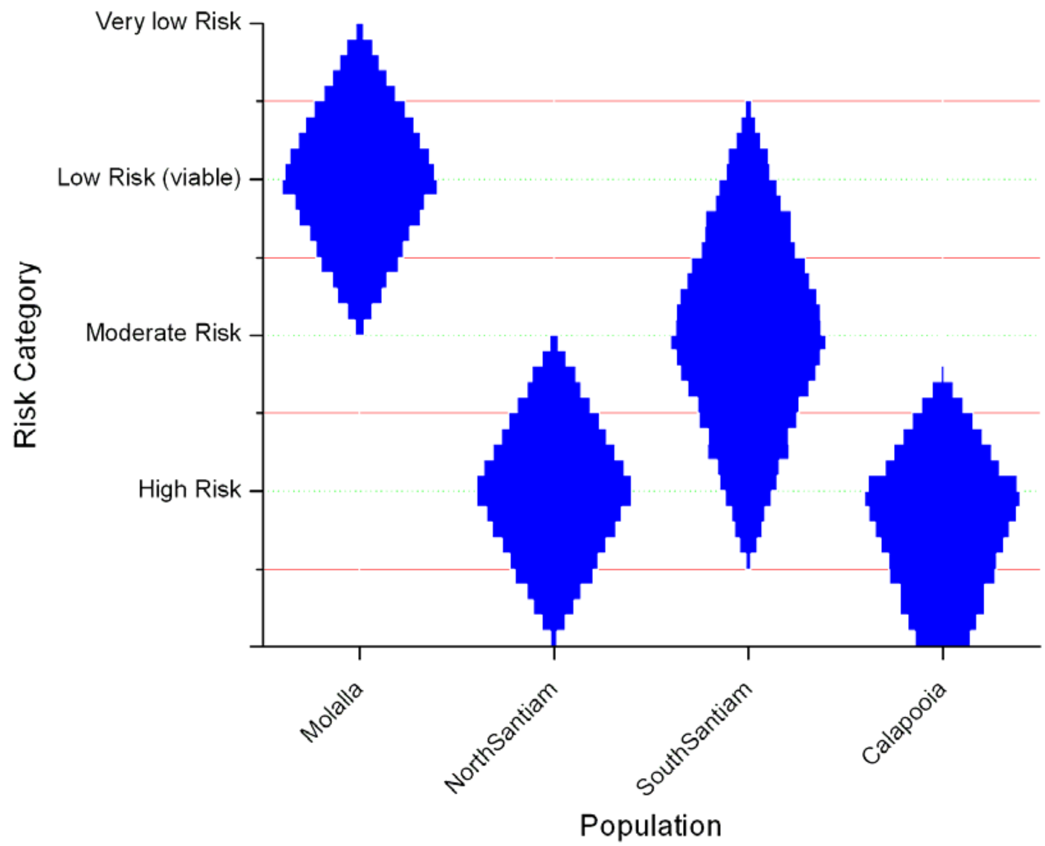

Figure 37: Summary of spatial structure risk scores for Upper Willamette steelhead.

IV. Diversity

DV – Background and Overview

Late-run winter steelhead are considered the only native run in the Upper Willamette River ESU. The same flow conditions at Willamette Falls (RKm 37) that only permitted access to spring-run chinook salmon also provided an isolating mechanism for this run time. Howell et al. (1985), however, reported that the peak passage time at Willamette Falls for "wild" winter steelhead is in April. Redd counts for late-run winter steelhead in the Willamette River Basin are conducted in May (Howell et al. 1985). ODFW currently uses February 15th to discriminate between native and non-native Big Creek (early-run) winter steelhead at Willamette Falls (Kostow 1995). Recent analyses of returning steelhead adults indicate that Upper Willamette River late-winter steelhead mature at four different ages: age 4 (48%); age 5 (41%); age 6 (10%); and age 7 (6%).

It is generally agreed that steelhead did not historically emigrate farther upstream than the Calapooia River (Fulton 1970). Since the Willamette Falls were laddered in the early 1900s, hatchery stocks of summer and early-run winter steelhead have also been introduced into the Upper Willamette River from other ESUs. In 1982, it was estimated that 15% of the late-run winter steelhead ascending Willamette Falls were of hatchery origin (Howell et a. 1985). Counts of native late-run steelhead moving past Willamette Falls had a 5-year geometric mean abundance of just over 3,000 fish (data through 1997) (ODFW 1998). All of the hatchery programs for steelhead were discontinued in the late 1990s, except for summer steelhead programs in the South Santiam, McKenzie, and Middle Fork Willamette River, where winter steelhead are not native.

The predominant tributaries to the Willamette River that historically supported steelhead include the Molalla (RKm 58), Calapooia (RKm 192), Santiam (RKm 174)—all drain the Cascades to the east (Mattson 1948, Nicholas 1995). The status of *O. mykiss* in basins that drain the Coastal Range is the subject of considerable debate. Although anadromous *O. mykiss* may occur in the Westside tributaries, it is generally thought that these are the progeny of introduced Lower Columbia River steelhead, or representative of sporadic occupation by native late-run steelhead. In this document and in the review of historical populations (Myers et al. 2003) spawning aggregations in the Westside tributaries are not considered demographically independent populations.

DV – Molalla River Winter-Run Steelhead

Life History Traits **–** Winter steelhead ascend Willamette Falls from December through May, with a peak in March and April (Firman et al. 2005). Although Big Creek (non-native) early-winter steelhead are no longer released in the Upper Willamette River, the presence of feral early-run fish may influence the characterization of late-winter run life history traits. Given the similarity in life history characteristics between early and late-winter steelhead it is difficult to identify whether there has been a change in late-winter life history characteristics or whether early-winter fish have been misclassified as late-winter fish. Score = NA

Effective Population Size **–** Recent escapement estimates for Molalla River steelhead are in the low thousands of fish (Goodson 2005). In general, several hundred fish returned annually to the Molalla River, except in the mid-1990s when escapement was below 100. Additionally, earlier escapement estimate did not distinguish between natural and hatchery-origin fish. Score = 3.

Hatchery Impacts

Hatchery Domestication – Releases of hatchery-origin late-winter fish were suspended in the late 1990s. Historically, hatchery production may have represented a substantial fraction of production. Genetic analyses indicate a close genetic affinity between winter steelhead populations in the Santiam, Molalla (North Fork), and Calapooia Rivers. Steelhead that are the progeny of summer-run and early winter-run steelhead are genetically distinct from presumptive native steelhead. Differences in spawn timing among these run-times may limit (but not eliminate) the potential for interbreeding. Score = NA.

Hatchery Introgression – The Molalla River has received introductions of three distinct runs of steelhead: native late-run winter steelhead, introduced early-run steelhead (from the Lower Columbia River), and introduced Skamania Hatchery summer-run steelhead (Chilcote 1997). Releases of the early-run steelhead into the Molalla River were discontinued in 1997 (Chilcote 1997), although some natural production of early-run winter steelhead may still occur. Overall, hatchery contribution to escapement has been near 40%, although currently it is near 0%. Score = 2-3.

Synthetic Approach – Hatchery releases into the Molalla River were discontinued in the late 1990s. Prior to that time, there were releases of non-native early-winter steelhead (Big Creek Hatchery) and summer steelhead (Skamania Hatchery), as well as late-winter steelhead from the North Santiam River. It is unclear to what extent these non-native releases have influenced the genetic diversity of the Molalla river steelhead. Currently the only strays into the Mollala River are likely from summer steelhead programs in the McKenzie and Santiam Rivers. Currently, Ph<0.05 although past hatchery introductions may have had an effect, especially when wild abundance was very low (<100) in the 1990s. Diversity persistence score = 3.0 - 4.0.

Anthropogenic Mortality **–** Historically, harvest rates for Molalla River steelhead has been near 20% (Chilcote 2001). With the recent introduction of selective fisheries this rate has fallen below 5%. Habitat changes in the Molalla River, Lower Willamette River, and mainstem Columbia River, may have influenced the expression of life history traits, especially juvenile traits. Score = 3.

Habitat Diversity **–** Historically, harvest rates for Molalla River steelhead has been near 20% (Chilcote 2001). With the recent introduction of selective fisheries this rate has fallen below 5%. Habitat changes in the Molalla River, Lower Willamette River, and mainstem Columbia River, may have influenced the expression of life history traits, especially juvenile traits. Score = ND/3.

Overall Score = 2.0. Many of the diversity concerns for this population are related to the legacy effects of hatchery releases from past years. There was considerable uncertainty in estimating these metrics. Additionally, habitat effects are largely unknown. Previously: 2004 TRT 1.51, 2004 ODFW Pass.

DV – North Santiam River Winter-Run Steelhead DIP Diversity Evaluation

Life History Traits **–** Winter steelhead ascend Willamette Falls from December through May, with a peak in March and April (Firman et al. 2005). Passage at Bennett Dam (North Santiam) normally peaks in April (Firman et al. 2005). Score = NA.

Effective Population Size **–** Overall, in recent years the escapement to the North Santiam River has included over 1,000 fish. Score = 3.

Hatchery Impacts

Hatchery Domestication – Surveys done in 1940 estimated that the run of steelhead was at least 2,000 fish (Parkhurst et al. 1950). Parkhurst also reports that larger runs of steelhead existed in the Breitenbush, Little North Santiam, and Marion Fork Rivers. Native steelhead were artificially propagated at the North Santiam Hatchery beginning in 1930, when a record 2,860,500 eggs (686 females x 4170 eggs/female) were taken (Wallis 1963). Production was somewhat intermittent during the 1940s. Attempts to capture all returning steelhead were unsuccessful due to the frequency and magnitude of spring floods (Wallis 1963). With the construction of Detroit Dam, the contribution of naturally-produced fish to escapement declined considerably. The release of hatchery propagated late-run winter steelhead was discontinued in 1998 (NMFS 1999). Recent escapements (through 1994) have averaged 1,800 fish, although the contribution of hatchery-origin fish was unknown (Busby et al. 1996).

Genetic analyses indicate a close affinity between winter steelhead populations in the Santiam, Molalla (North Fork), and Calapooia Rivers. Steelhead that are the progeny of summer-run and early winter-run steelhead are genetically distinct from presumptive native steelhead. Differences in spawn timing among these run-times may limit (but not eliminate) the potential for interbreeding.

PNI $\leq$ 0.84 (40 years hatchery production, PNI=0.80, 10 years no production) Fitness = 0.85. Score = 3.

Hatchery Introgression – Some summer steelhead are recovered in the North Santiam, and the effect of these fish on the native winter-run steelhead is unknown. Score = NA.

Synthetic Approach – Hatchery releases into the North Santiam River were discontinued in 1999. Prior to that time, there were releases of locally derived late-winter steelhead beginning in the1920s. Additionally, some summer run fish (Skamania Hatchery) are released in the North Santiam and South Santiam rivers. Currently, $Ph<0.05$ although past hatchery introductions may have had an effect. Diversity persistence score = 3.0 - 4.0.

Anthropogenic Mortality **–** Historically, harvest rates for North Santiam River steelhead has been near 20% (Chilcote 2001). With the recent introduction of selective fisheries this rate has fallen below 5%. Habitat changes in the Santiam River (especially thermal and flow conditions below Detroit Dam), Lower Willamette River, and mainstem Columbia River, may have influenced the expression of life history traits, especially juvenile traits. Score = 2-3**.**

Habitat Diversity **–** Habitat diversity loss is most severe for this DIP due to the loss of higher elevation spawning areas. Stream order was not determined. *(Order/Elevation)* Score = ND/1

Overall Score = 2.0. Major changes in habitat were thought to have had a significant effect on life history diversity. Other effects, such as the legacy of hatchery operations are difficult to estimate. Previously: 2004 TRT 1.46 , 2004 ODFW fail, 5 criteria met

DV – South Santiam Winter-Run Steelhead

Life History Traits **–** Winter steelhead are spawned at the South Santiam Hatchery during late April and May (Howell et al. 1985). The majority of returning adults are 2-ocean fish (84%), 3-ocean fish (16%) (Howell et al. 1985). Score = NA

Effective Population Size **–** ODFW considers the late-run winter steelhead in the South Santiam River to be one population, although Foster Dam may influence the distribution of spawners in the river (Chilcote 1997). Natural spawners above and below Foster Dam are monitored as distinct units and appear to be demographically independent. Currently, the combined escapement to the South Santiam is a few thousand fish, 2296 (2000-2004), but during the mid-1990s the average near 1,000 (Goodson 2005). Score = 3.

Hatchery Impacts

Hatchery Domestication – Native late-run winter steelhead and introduced Skamania Hatchery summer-run are both present in the south Santiam River. Hatchery releases of winter steelhead have not occurred in this basin since 1989, and the proportion of hatchery-reared fish that currently spawn naturally in the South Santiam River is believed to be less than 5% (Chilcote 1997), although prior to 1989 it was over 40% (Goodson 2005). Hatchery operations began in 1926, and in 1940 a record 3,335,000 eggs were taken from 800 females (Wallis 1961). The run size at this time was probably much larger because it was not possible to install the weir in the river until much of the run had already moved far upstream (Wallis 1961).

Genetic analyses indicate close genetic affinity between winter steelhead populations in the Santiam, Molalla (North Fork), and Calapooia Rivers. Steelhead that are the progeny of summer-run and early winter-run steelhead are genetically distinct from presumptive native steelhead. Differences in spawn timing among these run-times may limit (but not eliminate) the potential for interbreeding. PNI ≤ 0.84 (40 years hatchery production, PNI=0.80, 10 years no production). Fitness = 0.85. Score = 3.

Hatchery Introgression – Large numbers of summer-run steelhead (Skamania Hatchery stock, out-of-ESU) are released into the South Santiam River. In 2003, 11,493 summer steelhead returned to the South Santiam Hatchery. Although differences in spawn timing may limit the potential for genetic introgression, it is unclear how competition between summer and winter steelhead juveniles or adults may influence the expression of life history traits. Score = NA.

Synthetic Approach – Hatchery releases of locally-derived late-winter steelhead into the South Santiam River were discontinued in 1989. Currently, over 100,000 summer run fish (Skamania Hatchery-origin) are released from the South Santiam. Winter steelhead that arrive at Foster Dam are transported above the dam, although summer steelhead are not. This effectively creates two zones in the South Santiam River, below Foster Dam where summer and winter steelhead com-mingle and above Foster Dam where only naturally-produced (unmarked) fish are allowed. Currently, $Ph< 0.05$ above Foster Dam, but likely $0.10<Ph<0.30$. Diversity persistence score = 3.0.

Anthropogenic Mortality **–** Historically, harvest rates for South Santiam River steelhead has been near 20% (Chilcote 2001). With the recent introduction of selective fisheries this rate has fallen below 5%. Habitat changes in the Santiam River (especially thermal and flow conditions below Detroit Dam), Lower Willamette River, and mainstem Columbia River, may have influenced the expression of life history traits, especially juvenile traits. Score = 3.0**.**

Habitat Diversity **–** Habitat diversity loss is most moderate for this DIP due to the loss of higher elevation spawning areas. Stream order was not determined. Score (*Order/Elevation*) = ND/3.

Overall Score = 2.0. The legacy of hatchery operations in combination with the continued release of summer-run steelhead presented notable risks. Additional concerns included the loss of habitat diversity.

Previously: 2004 TRT 1.59; 2004 ODFW Fail, 5 criteria met.

DV – Calapooia River Winter-Run Steelhead

Life History Traits **–** No information available. Score = NA.

Effective Population Size **–** Willis et al. (1960) reported that both live and dead steelhead were observed in the Calapooia River on 12 May 1958, in addition to 427 redds.

In 1993, spawner density estimates for the Calapooia River were at a record low, 1.8 spawners per mile (Chilcote 1997). The average escapement of late-run winter steelhead to the Calapooia River reached critically low levels during the mid-1990s (1993-1997) with returns of 61 fish (ODFW 1998). In the last four years escapement has reached several hundred fish (427) (Goodson 2005). Score = 1-2.

Hatchery Impacts

> *Hatchery Domestication* – There is no hatchery program on the Calapooia River. Chilcote (1997) estimates that hatchery fish (predominately strays from other Upper Willamette River DIPs) constitute less than 5% of escapement.
>
> Genetic analysis indicated a close affinity between winter-run steelhead in the Calapooia River and native late-run winter steelhead in the Santiam and Molalla basins. Score = NA
>
> *Hatchery Introgression* – The incidence of stray hatchery fish, summer-run steelhead, or winter-run steelhead from other basins in the Upper Willamette River is thought to be low, although given the low escapement even a few fish could have a significant influence on the population. Score = 3-4.
>
> *Synthetic Approach* – There are currently no hatchery releases of steelhead into the Calapooia River. The proportion of hatchery fish on the natural spawning grounds is thought to be low (P_h<0.05) although the genetic similarity would be very low. Diversity persistence score = 3.0 - 4.0.

Anthropogenic Mortality **–** Historically, harvest rates for Calapooia River steelhead have been low, near 10% (Chilcote 2001). With the recent introduction of selective fisheries this rate has fallen below 5%. Habitat changes in the Calapooia, Lower Willamette River, and mainstem Columbia River may have influenced the expression of life history traits, especially juvenile traits. Score = 3-4**.**

Habitat Diversity **–** Habitat diversity loss is most moderate for this DIP due to the loss of higher elevation spawning areas. Stream order was not determined. Score*(Order/Elevation)* = 3-4.

Overall Score = 1.5. Small population size appears to be the greatest threat to diversity. Abundance is low enough that genetic drift, introgression with non-local fish, and selection could dramatically influence genetic variation in this population.

Previously: 2004 TRT 1.78; 2004 ODFW Pass.

DV – Criterion Summary

With respect to the diversity criterion evaluation, populations in this ESU were all classified into the 'moderate' risk category (Figure 38); although, in the case of the Calapooia population, a classification of 'high' risk may be an equally appropriate determination. The loss of genetic resources because of small population sizes and loss of historically accessible habitat are the primary factors that resulted in the DV criterion population ratings.

The uncertainty associated with these population scores for the DV criterion was relatively small. Given this result and the individual populations scores themselves, we conclude that the most probable risk classification for these populations (and ESU) with respect to the SS criterion is 'moderate'.

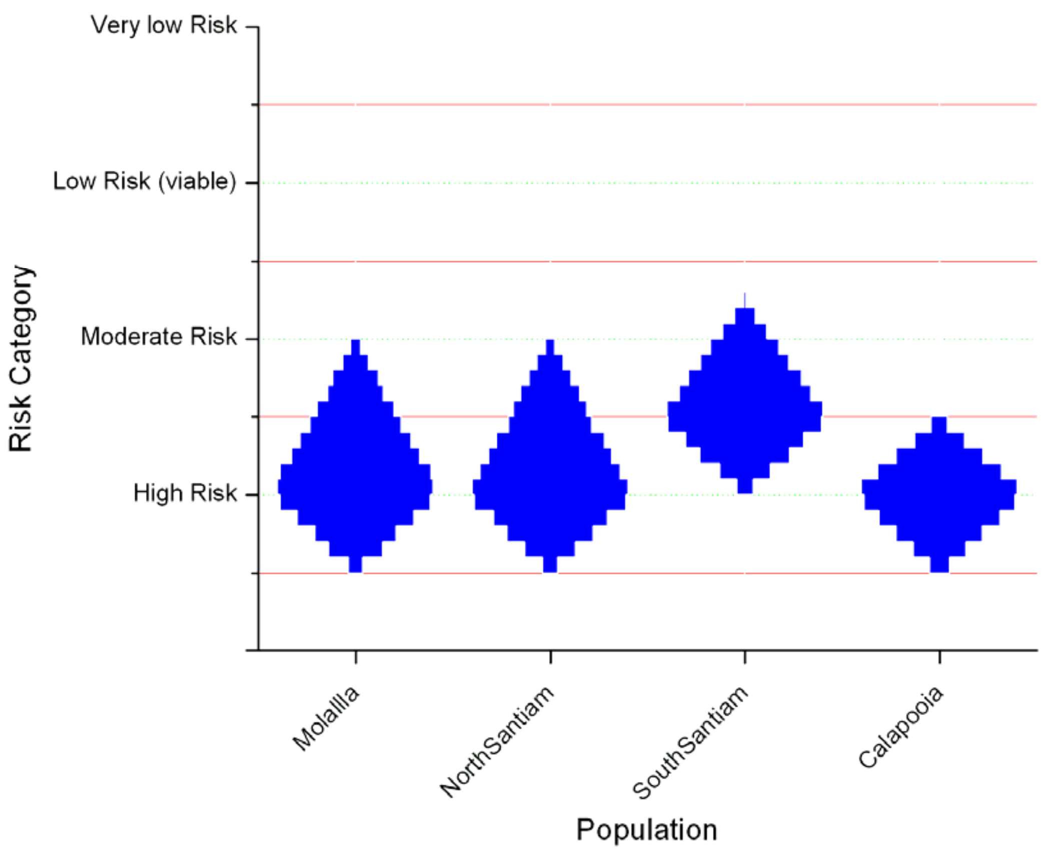

Figure 38: Summary of diversity evaluation for Upper Willamette steelhead populations.

V. Summary of Population Results

When the scores for all three population criteria were combined, we concluded that the most likely risk of extinction for all UW steelhead populations is moderate (Figures 39 and 40). However, there is considerable uncertainty in these population risk estimates. Based on this analysis, we conclude that the overall extinction risk for the UW steelhead ESU is moderate.

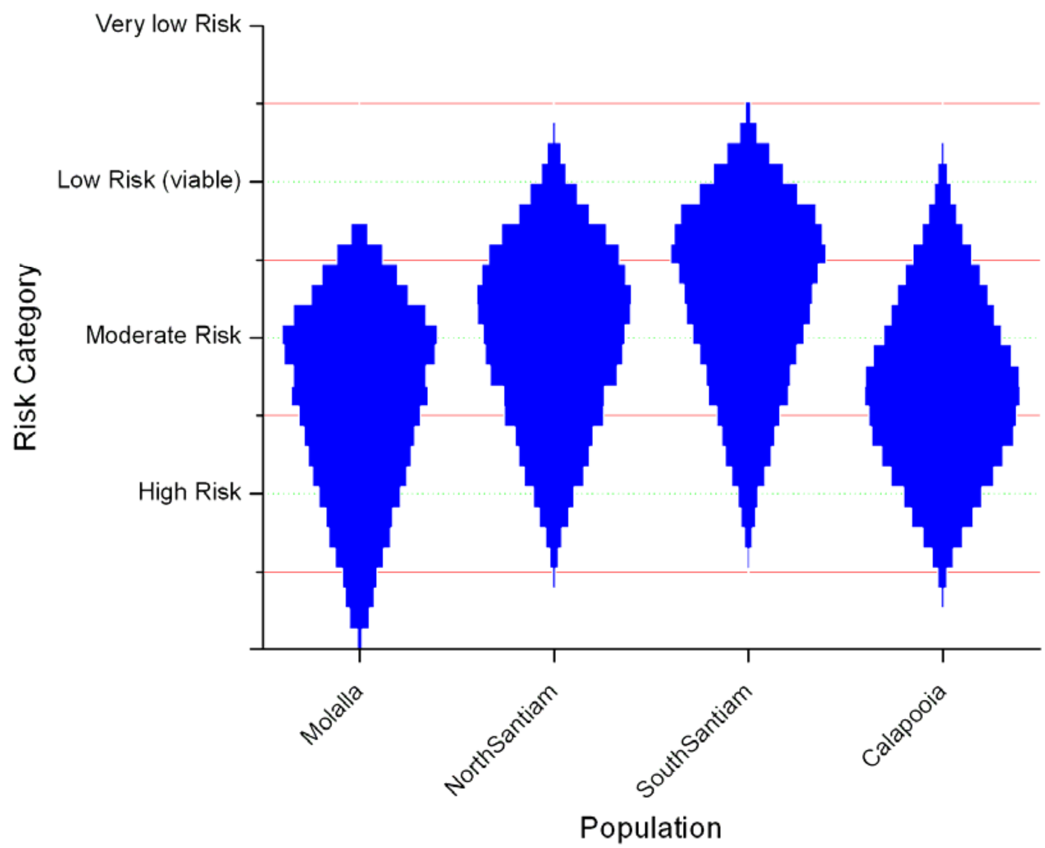

Figure 39: Overall population status assessment for Upper Willamette steelhead using the minimum distribution approach.

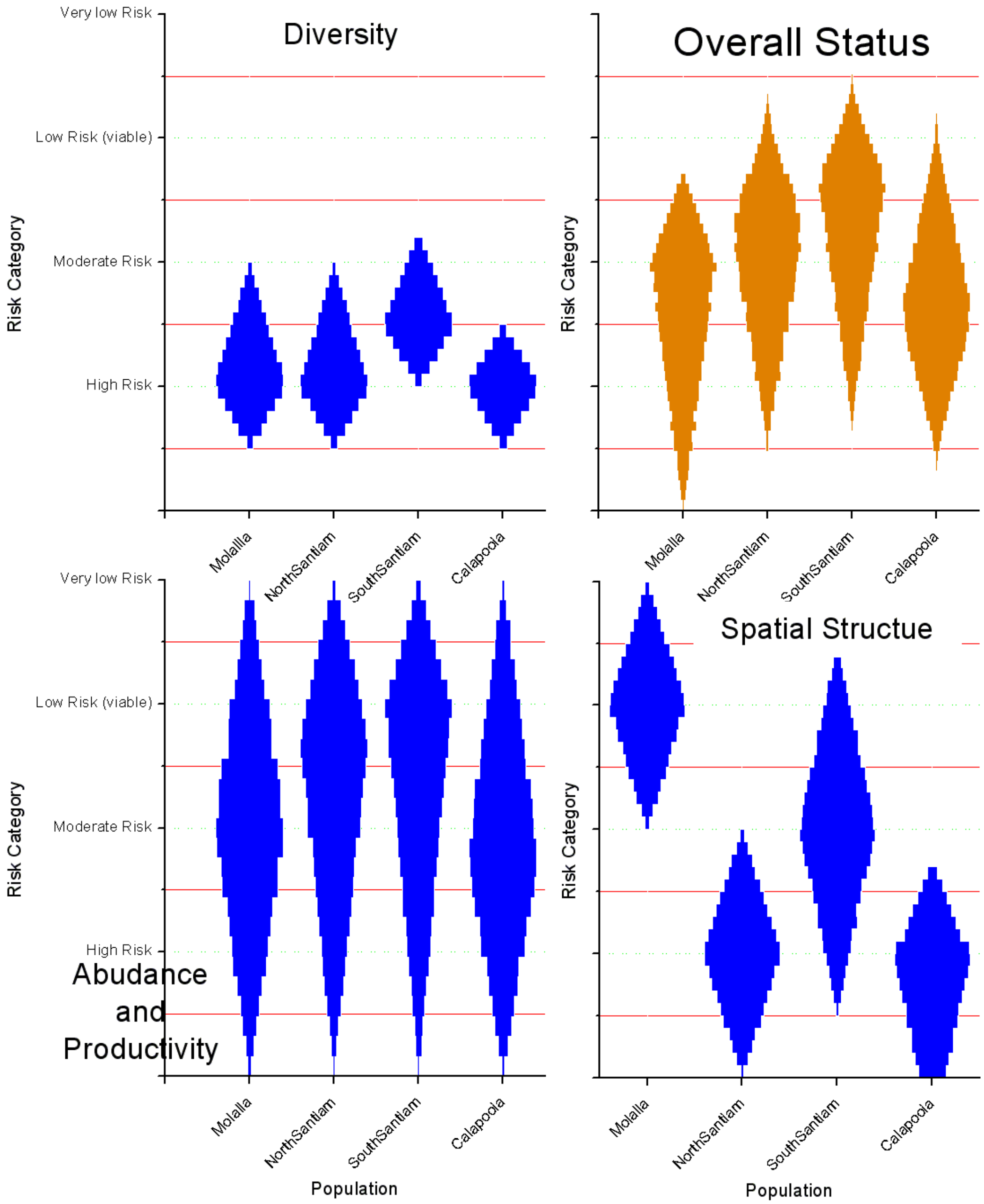

Figure 40: Upper Willamette steelhead status graphs of each attribute and the overall summary.

Literature Cited

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ODFW. 2005. 2005 Oregon native fish status report. ODFW, Salem, OR.